JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXIV.] NOVEMBER, 1872. No. 6

EDITORIAL.

ITEMS AND NOVELTIES.

The Stevens Institute of Technology.—*Continued* from p. 222.—Ascending to the third floor, and beginning as before at the west side, we first enter room No. 22 (see plate), in the wing which is devoted to mineralogy and blow-pipe analysis.

Here are arranged, in large cabinets, a collection of 3000 selected and classified specimens, of 600 large specimens showing the including rocks and association of minerals, and a numerous and carefully prepared assortment of unlabeled specimens to be determined by students in course of their work in this department.

Here also is a large table provided with gas-burners and blow-pipe apparatus to accommodate a class of students, who can thus receive direct practical instruction in the use of the blow-pipe, and the determination of minerals and ores.

A Desaga spectroscope, with burners, etc., is also conveniently arranged on a shelf against the wall, and the windows are provided with adjustable shelves carrying various forms of goniometer and polariscope for the minute study of crystals.

Opening from this room is the study of the Professor of Chemistry, which contains, besides his writing-table and book-case, a fine analytical balance by Becker.

Opening again from this, we find the Professor's private laboratory, which is provided with laboratory tables, with their characteristic bottle-racks and numerous drawers, with extensive sand-baths and evaporating-closets, and with filter-pumps, air-blast, oxygen and hydrogen gases, and the like.

Returning to the main building, we pass a small room, No. 23, fitted with marble wash-basins, and entering No. 24, find it filled with drawing-tables and cases for drawings, drawing-boards and instruments. The same is the case with No. 25, No. 26 and No. 27, all these rooms being provided with skylights.

No. 28 is the study of the Professor of Drawing.

Entering No. 29, we find its windows arranged for the use of a port-lumiere, and several spectroscopes and related apparatus distributed and in use on tables before them.

At one side is also set, in permanent adjustment, the Thompson reflecting astatic galvanometer, which is the instrument used for transmission of messages across the ocean cable, and for measurement of electrical resistance in the most delicate manner. In connection with this is a water-battery of 550 cells, and a condenser of microfarads, and a large set of resistance coils.

We were shown, as an illustration of the delicacy of this galvanometer, that a single cell of the water-battery, acting through a resistance of 10,000 ohms or units, and then so divided that but $\frac{1}{10000}$ part passed through the instrument, produced a deflection of 70 scale divisions.

No. 30 is a store-room, and No. 31 a photographic studio, with its camera lenses, dark room, etc.

We saw a number of excellent interior views of various rooms in the building, made here by Prof. Leeds, who has this apartment under his especial charge.

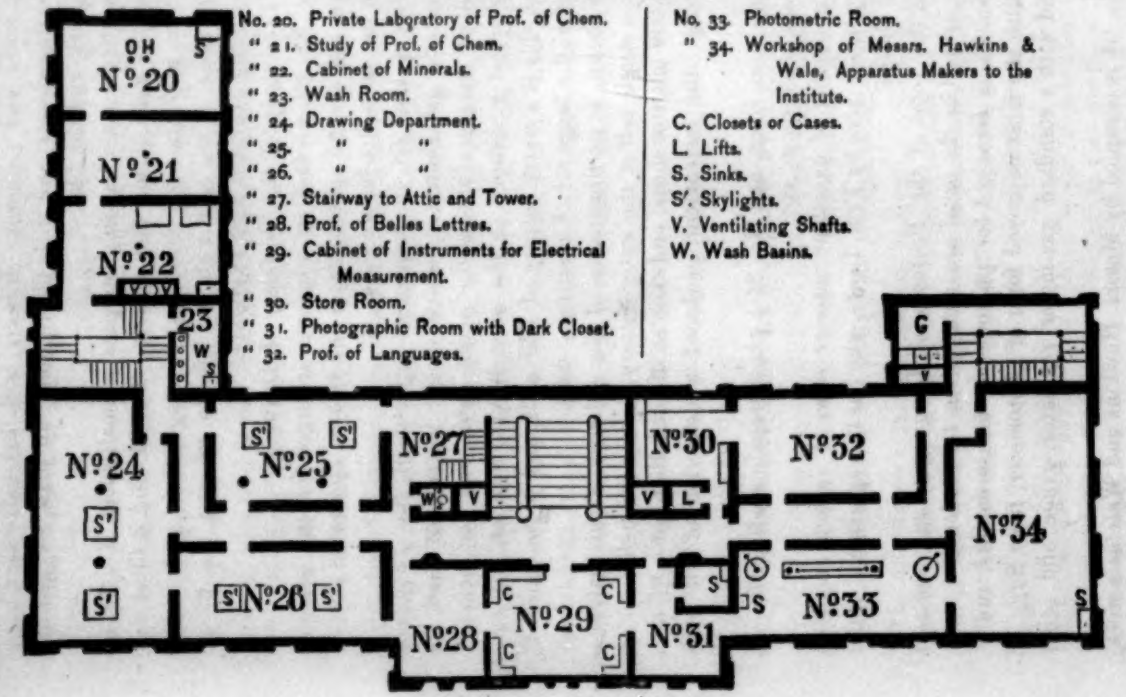
No. 32 is the room of the Professor of Languages, and contains his library, as well as the usual accommodations for students.

Room No. 33 is arranged for photometric measurements, and is furnished with the most improved form of photometer, from Sugg, of London, and with a standard gas-meter regulator, gauge and other appliances.

Room No. 34 is occupied by Messrs. Hawkins and Wale as a work-shop, and is thoroughly fitted with a number of lathes, a planer, shears, glass-grinding apparatus, work-benches, and all sorts of tools. Here are manufactured the little pocket spectroscopes which are now

THIRD FLOOR.

Stevens Institute of Technology.



THIRD FLOOR.

so largely used by all chemists and physicists, also the vertical lanterns of the convenient and efficient form devised by these manufacturers, and also sets of blow-pipe apparatus such as heretofore have only been imported.

To the Institute, with its immense collections of apparatus, which must constantly require repair and adjustment, the advantage of such an establishment under its own roof is sufficiently evident.

Since this notice was begun another wing has been added to the building described.

This is located on the east side, and corresponds in a general way with the wing on the west, occupied by the rooms of the chemical department.

It is 60 feet deep by 30 feet wide, and contains in all thirteen rooms, a portion of these forming the Janitor's house, and others accommodating a preparatory school of some thirty pupils, under the charge of Prof. Wall.

In conclusion, and after such a thorough survey as we have made, we can only say, as no doubt does every visitor who inspects it, that in its unity of plan and thorough completeness in every detail, this establishment stands without a rival, and can hardly fail to be the most enduring and worthy monument to its munificent founder.

The Centennial Exhibition.—The following communication, addressed to the President of the Institute, explains itself too well to require editorial comment:

1776.—INTERNATIONAL EXHIBITION, PHILADELPHIA.—1876.

OFFICE OF THE UNITED STATES CENTENNIAL COMMISSION,
PHILADELPHIA, PA., *October*, 1872.

COLEMAN SELLERS, ESQ., *President of the Franklin Institute, Philadelphia, Pa.*:

The Anniversary of the Independence of the United States in the year 1876, is to be celebrated by an exhibition of the products, arts and industries of the country and of the world. This is in accordance with an Act of Congress approved March 3d, 1871. By this act the task of preparing and superintending the exhibition was imposed upon the United States Centennial Commission, consisting of two members from each of the States and Territories. The Commissioners have twice met in general session, a permanent organization has been effected, and the chief outlines of the plan for the exhibition have been agreed upon.

This exhibition is to be international and universal—international inasmuch as all nations will be invited to participate in it; and universal, because it will include a representation of all natural and artificial products, all arts, industries and manufactures, and all the varied results of human skill, thought and imagination.

The outlines of a simple yet comprehensive classification have been adopted. There will be ten departments, each subdivided in ten groups, and these again into classes. The details of this classification are now being elaborated, and will be published in due season, together with such rules and regulations as may be found necessary for the proper conduct and management of the exhibition.

It is intended that ample space shall be assigned to each State, Territory and foreign country, for a just and proper display of their products. It is believed that not less than fifty square acres of floor space, under roof, will be required for this purpose. A site combining the advantages of a sufficient extent of level ground, with picturesque and cultivated surroundings, easy of access by rail, water, and by ordinary roads, has been assigned for the buildings and grounds at Fairmount Park, in the City of Philadelphia. The exhibition will open in April, and close in October.

Each State of the Union will be expected to send its peculiar products, illustrating its resources, both developed and undeveloped. A complete exhibition of this kind by all the States, will afford the means of comparing their industrial condition and capabilities. The products of mining and of agriculture will occupy a large portion of the space allotted to each State, and will receive their just share of attention in this universal display.

An undertaking so patriotic in its conception, so vast in its proportions, and so useful in its results, commends itself to the hearty sympathy and support of an intelligent people. Patriotism, as well as an appreciation of the industrial, educational and moral influences of well-organized exhibitions, should impel all citizens to lend a helping hand. It is the duty of the Commission to prepare the way and open the doors, but the people, in their sovereign right and strength, must make the exhibition. By their aid, alone, can it be made a just and comprehensive display of the industrial, intellectual and moral development of the Nation during the first century of its existence.

The Commission not only relies with confidence upon the aid of the people in general, but it hopes to receive the co-operation of the many State societies and organizations which for so many years have aided in directing and realizing the popular demand for agricultural and industrial exhibitions. The desire to secure, at an early date, your efficient co-operation, has led to this communication, which is made at the request of the Executive Committee of the Commission.

Permit me, in closing, to suggest that the facts herein stated might, with great advantage to the exhibition, be communicated as publicly as possible to your members and exhibitors, and that, if agreeable, they should be incorporated in your *Journal*. A committee of your members might be appointed to consider and suggest such measures as may appear most desirable to promote the success of the object for which the Centennial Commission is appointed. A general plan for the organization of Co-operative Centennial Associations in the several States and Territories is now under consideration, and when perfected will be published for distribution.

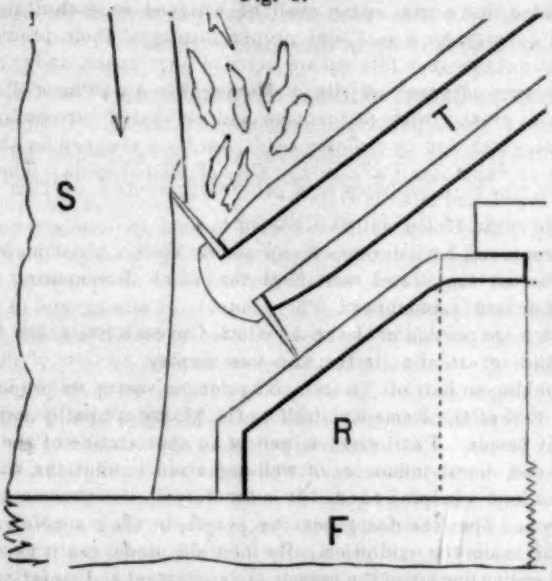
Please acknowledge the reception of this communication.

Very respectfully, your obedient servant,

WM. PHIPPS BLAKE, *Executive Commissioner.*

Turning Tool for Dressing Grindstones.—The accompanying illustrations represent a tool of this description, designed and patented by J. E. Mitchell, of this city, and exhibited and described before the last meeting of the Franklin Institute.

Fig. 1.



In the sectional view, S represents the stone, the arrow giving the direction of its rotation towards the tool, which is held at such an angle as to cut under the surface of the stone. The cutter is a disc of tempered steel, chamfered on the inner side up to a sharp edge, with a square hole to prevent turning on the handle. T is a bar of round iron, with a head forged on the square end, to which the cutter is fitted. This bar passes through and is bolted to the hollow handle of the tool. R is the tool-rest, screwed to the base, F, and so constructed as to be moved closer as the stone wears away.

The object of this tool is to turn off stones of any kind and to any required shape. Columns may be turned off perfectly true, and any form of mouldings may be given to bases and capitals, or to balusters, vases and other forms of ornamental work in stone. The stone is roughly rounded off and hung upon proper centres, and caused to revolve slowly. The tool is held on the rest at such an angle as to cut under the surface of the stone, and reduce the same to the desired form by peeling off layers in small scales. The stone can then be

finished with sand and water, and polished in the usual way. In this manner stones may be shaped much more readily than by the use of ordinary tools, which only exert a scraping action. This tool is especially adapted for turning and trueing grindstones in machine-shops, as it makes little or no dust, and having been used very extensively for this purpose in the extensive establishment of the designer, its efficiency has doubtless been thoroughly tested.

The Vienna International Exposition.—The following announcement of the Advisory Committee of the U. S. Commissioner, upon the department of machinery, will, we are sure, be read with interest by machine builders and others interested in this branch of industry throughout the United States:

The International Exhibition to be opened at Vienna, Austria, May 1, 1873, will be by far the largest and most important of all international expositions yet made or definitely announced.

It is under the direction of the Austrian Government, which has erected immense buildings at the Prater, and has granted the use of the extensive parks and public gardens of Vienna. The covered space will be several times as great as that of the Paris Exhibition of 1867, and all the European nations have already demanded still greater space than that assigned them.

The Austrian Government is exceedingly desirous that the United States shall be well represented, and makes extraordinary concessions to American manufacturers. The Austrian patent law is practically abrogated for the six months of the exhibition, and two months following, and inventors are protected, by a special ordinance, against piracy of their inventions. It is further expected that a special treaty may be entered into by the Governments of Austria and the United States, which shall afford full protection to American patentees in future. Under the treaty concluded between the two nations April 22d, 1872, American trade-marks protect their patentees in Austria as fully as in the United States.

The opportunity here offered to American inventors and manufacturers is a most valuable one, not only as affording an opportunity to exhibit their apparatus and machinery to all eastern European nations, but as promising such a series of valuable notices, in all the engineering periodicals of the world, that every intelligent purchaser and consumer will be advised of the peculiarities of all really valuable machines, whatever his language or his location.

The exhibition will be visited by many hundreds of thousands of people, and it may be confidently expected that, in many cases, it will occur that manufacturers sending articles from the United States will find their home market so considerably enlarged, by favorable reports brought from Vienna, as to make the outlay a remunerative one, even were they to secure no orders from abroad. The proportion of American visitors at European international exhibitions is always very large.

At the Vienna Exhibition the machinery of the United States section should be driven by an American steam engine, and every branch of our manufacturing industry should be represented in full by our best builders.

We have the best stationary steam-engines in the world; our systems of transmission of power are exceedingly well-devised; our mining machinery is, in many respects, superior to anything seen abroad; our apparatus for use in the manufacture of textile fabrics possesses many points of special value and interest; we have metal- and wood-working machinery which excels in efficiency, and which is universally admired for the ingenuity displayed in making it at once simple in form, strong, and cheap of construction, and wonderfully effective. Our steam fire-engines, steam-pumps, and our railroad machinery; our household apparatus, and the wonderful variety of labor-saving and of small machinery for domestic purposes, which are observed in our market, should all be found at the coming international exhibition at Vienna.

It is understood that Austria has appropriated to the enterprise over six millions of dollars; Italy has appropriated two millions, and the other European Governments in proportion.

It is hoped that our Government may yet be induced to exercise an intelligent liberality in assisting the United States Commissioner in his effort to aid manufacturers.

No expenses will be laid upon exhibitors, so far as the undersigned is advised, except such as may cover transportation, unpacking, placing on exhibition, storing boxes, repacking and reshipping, and insurance. No charge will be made for services by the Commissioner or the Assistant Commissioners, except that exhibitors will be expected to pay the expenses of unpacking and placing goods, which will be done by an Assistant Commissioner, and at a rate much lower than if done by different parties. Any one desiring to exhibit will, at at the earliest moment, make an application to the Commissioner, in writing, stating exactly what articles he proposes to send and the space required.

Articles will be placed in the exhibition building between the 1st of February and the 15th of April, 1873. Arrangements have been made with the steamship lines and railways for reduction on freights, which will be made public when ascertained.

It is most earnestly hoped that, for the credit of the nation, our countrymen will largely avail themselves of the privileges offered, and fill the American department with the choicest specimens of their skill, industry and enterprise.

Manufacturers of machinery will address T. B. Van Buren, Commissioner for the U. S., 51 Chambers street, New York, or the undersigned,

R. H. Thurston, *Chairman Group* 13, *Advisory Committee,*
Stevens Institute Technology, Hoboken, N. J.

An Elastic Combination Frog.—The object of this invention, of which engravings are here presented, is to produce an elastic frog that will have a continuous connection with the rails, and thus greatly lessen if not altogether avoid the usual shock experienced in passing trains through them, and one which shall permit of being readily renewed.

The bed is made of cast-iron (of about 650 lbs. for a 6-feet frog), with pockets in either end in which to secure the rail. On the top of

this bed is fitted a solid cast-steel cap (200 lbs.), which is let into the bed in such a way as to prevent either lateral or end motion, and, as an additional security, is attached to the bed by bolts with lock nuts.

Between the cast-iron bed and the steel cap is placed the elastic material, extending over the whole surface of the frog. The accompanying cut shows the lower surface of the steel cap to which it is attached (Fig. 1). Wood or rubber is the material of which the elastic medium is composed by preference, one-eighth of an inch of either, we are assured, being sufficient to break the shock of passing wheels.

Fig. 1.

Fig. 2.

The bed is so constructed as to prevent the working out of the elastic material, and its duration is said to be as great as that of the steel cap, which last depends of course upon the amount of service to which it is subjected (Fig. 2).

The continuous connection of the frog is obtained by continuing the wing rails of the steel cap past and outside of the ends of the connecting rails. In practice, 4 inches is stated to be sufficient to prevent shock from that quarter, as also to prevent the lamination of the ends of the connecting rails. The heel of the steel cap is permitted to pass between the two connecting rails, and thus secure the continuous connection at that end.

Should it be found needful to renew the cap, it is only necessary to unscrew the bolts confining it to the bed, to remove it and place a new cap in its place, without disturbing the remainder of the frog—thus avoiding, it is claimed, much of the delay to trains incident to such repairs, and considerable expense in the number of workmen required. The renewal required from time to time being only of the steel cap, the expense attendant upon it will only amount to 30 per cent. of the original outlay, it being premised that the bed is made sufficiently strong to withstand fracture, except under a continued unusually severe strain.

These frogs are at present in operation in many roads throughout the country, and it is said have been found to be eminently satisfactory in their operation. The invention is known as the Pierce Elastic Combination Frog, and the headquarters of the manufacturers is at Cincinnati, where, at the late industrial exhibition, the device attracted much attention and comment.

The "Steam-Jacket."—At the recent meeting of the Manchester Scientific and Mechanical Society, an interesting discussion was had on the subject of the utility of the steam-jacket.* The question at issue was whether the unavoidable liquefaction of steam due to condensation from radiation, conduction and convection, and that due to the work of the engine, was to be allowed to take place in the cylinder itself, or whether it was more advantageous to employ a separate casing to supply heat to the steam inside the cylinder, and let the condensation take place in the casing, so that the propelling steam was uninfluenced by loss of heat from radiation. Condensation would take place under all circumstances, even if we could construct the ves-

* Van Nostrand's Mag., vii, 553.

sels in which the steam had to perform its work of perfect non-conducting materials. So far from being able to do this, it was evident that the liquefaction due to radiation and conduction would be greater where a steam-jacket was used, owing to a somewhat larger radiating surface of the jacket, and more than double the quantity of metal to be treated where the jacket was applied. But it was thought by many eminent observers that the evils arising from the influence of convection in the cylinder did more than balance those due to increased radiation and conduction. If there was an advantage in point of economy, it was a doubtful one, notwithstanding that we saw nearly all the steam-engines in open competition trials, steam-jacketted or with hot-air jackets. Jackets, too, increase, to a not inconsiderable amount, the first cost of an engine.

The result of the discussion may be summed up as follows: All the members present, with one exception, subscribed to the statement, "That no advantage could be gained with the steam-jacket, nor did they object to its use; but they were convinced that efficient protection against radiation and conduction from the cylinder was the best and only means of obtaining true economy."

Whitworth's Compressed Steel.—Our English contemporaries contained recently some accounts of trials of this new material in the form of field-guns, which it is asserted proved most conclusively its extraordinary tenacity.

The process consists, in general terms, in applying great pressure upon molten steel in the process of cooling, by means of hydraulic presses.

The results of the gun trials, it is asserted, have not only shown the suitability of the new material for guns, but have left no doubt that the remarkable strength shown by it will secure its introduction for purposes other than those of war.

A Safety-Shoe for Railroad Cars and Engines.—This device, which was viewed in operation some weeks ago by many of the members of the Institute, is the invention of Messrs. Emery & Doyen, of Portland, Maine, and consists of two parallel runners attached to the under surface of the truck, the ends of which are turned up. Through the bottom of the shoes, which have openings cut in them for this purpose, the wheels project to bear upon the rails, and each shoe is provided with a flange upon either edge, while a space is left between wheel and flange a little greater than the width of the rail.

When the wheels from any cause slip the rail, the shoes drop down on the rails and support the cars, and are prevented from leaving the rails by the flange; while, owing to their broad bearing surfaces, it is claimed that the train will be at once powerfully retarded in its motion from the friction so produced.

The object of the invention is stated to be to prevent cars from being thrown from the track by misplaced switches, broken rails, axles, wheels, &c, and thus to throw an additional safeguard about railroad travel.

Coal-Cutting Machinery.—One of the difficulties incident to the introduction of coal-cutting machinery is the great cost in large mines of laying down pipes from the surface to convey the air into the pit, and thence to that part of the workings where the machinery happens to be in use.

To overcome this difficulty it has been proposed by Messrs. Simpson & Hurd to employ a portable air compressor, to be used in any part of the mine, to be operated either by animal or manual power.

Metallic Paper Hangings.—A plan for substituting metal sheets, decorated with ornamental painting of any kind, for ordinary wall paper, has lately been brought to public notice by a French firm.

The material used is tin foil, in sheets of the thickness of writing paper, and upon this, decorative work of any kind, even gilding, can easily be affixed. The sheets are pliable but tough, and offer a smooth surface, upon which the design can be attached without difficulty. The material, it is said, can be attached to walls of any kind, wood, metal, plaster, stone, &c., and is made to adhere by a thin coating of varnish. This last adds to the impenetrable character of the metal hangings, rendering them extremely serviceable in covering damp walls. These new hangings are said to be of extreme beauty, and to be in every respect superior to the old forms of paper hangings, for which they are offered as a substitute.

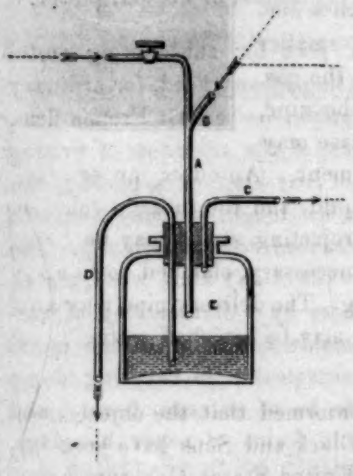
In the same general direction it is interesting to note the recent advances which have been made abroad in the art of printing upon textile fabrics by precipitation upon them of metals in finely divided state.

Lime as a Preserver of Wood.—A writer to the Mechanic's Magazine calls attention to the fact that lime, used in connection with ship timber, acts as an excellent preservative. In connection with

the subject, it is stated that a coasting schooner, built of Maine timber, unseasoned, and loaded with lime, had gone ashore and bilged. Being raised some time after, the vessel remained sound for thirty years, with the exception of those parts which had been employed in making repairs. It has already been noticed that vessels employed in carrying lime last longer than others. The most striking case mentioned by the writer is that of a platform of nine planks, used to mix mortar on, and which had been employed by father, son and grandson, and which, finally being no longer needed, was suffered to remain on the ground, and became overgrown with grass. After a period of sixty years, having occasion to use the ground, the planks were found to be still perfectly preserved.

These statements, if verified, are certainly sufficiently suggestive to warrant more extended employment of this material as a preserver of wood than has heretofore been made.

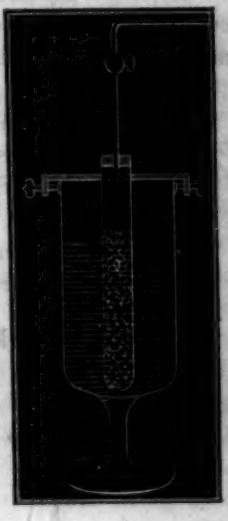
A Water Blowpipe.*—A contemporary figures the following for a simple water blowpipe, which, though differing in no wise from the apparatus usually employed, may still possess some interest to those of our readers who are interested in looking after useful adjuncts to the laboratory. A is the water supply pipe, with short branch pipe, B, attached, through which the air is drawn by the falling column of water. This, as well as the other tubes to be named, is firmly attached to a reservoir E. A siphon tube, D, and an exit pipe for the air, E, complete the apparatus. The water column parts with its air upon reaching the reservoir. The air under pressure is forced out at C, thus affording the blast, which can be increased in strength by lengthening the water column; while the siphon tube empties the reservoir as rapidly as the feed pipe supplies it.



Automatic Gas Generator.—The frequent employment in the laboratory of the gaseous reagents, hydrogen, carbonic acid, sulphu-

* Am. Journ. Pharm., iv s., ii, 451.

retted hydrogen, &c., render it a matter of no little moment to the analyst to be in possession of portable automatic generators to supply his wants at a moment's notice. For those laboratories where the student manufactures these reagents by turning on a green, red or blue stop-cock, the following description of a generator which is very convenient for the purpose, and easily rigged up, will be of no service, but it may be found of some use in workshops where the old-fashioned way of making things when they are needed is still the rule.



It is on the old plan of displacing the generating liquid with the aid of a closed bell within an outer vessel.

A wide piece of glass tubing is heated and slowly drawn out before the blast-lamp until almost closed, then filed off, leaving a slight opening. This portion of the tube is then cut off at the top, at proper length, and fitted with a perforated stopper, in which is placed a smaller tube, with stop-cock for the delivery of the gas. The wide tube is first provided with the zinc, marble or sulphide fragments, as the case may be, and closed with the delivery attachment. An outer jar or vase may be used to hold the generating liquid, and the tube provided at its upper rim with a brass ring and projecting strips may be hung from the top of the jar, and, if thought necessary, clamped down upon it, as shown in the accompanying drawing. The delivery pipe may also be provided with a drying tube, which may be attached vertically or horizontally, as most convenient.

The Great Telescope.—We are informed that the object-glass for the great telescope which Alvan Clark and Sons have been for some time past engaged upon, for the United States Government, is at length completed.

The two lenses composing it are 27½ inches in diameter, of which 26 inches will be available for optical purposes, the outer inch and a half being covered by the mounting.

The crown glass is without flaws, and, a few air-bubbles excepted, is optically perfect. In the flint lens there are a few striæ; but, considering the great size of the glasses, they may both be regarded as near perfection as it is possible to attain.

When completed, this magnificent instrument will be placed at Washington, in the charge of the officers of the U. S. Naval Observatory, in whose efficient charge it will doubtless render good service in advancing American astronomy. The most extraordinary care is observed at the manufactory to preserve this remarkable glass (which we believe is the largest in the world) from accident, and when properly mounted it will prove a noble monument of the skill of its famous maker.

Mineralogical Notes.—v. Zepharovich describes, under the name of Syngenite, a new mineral closely related to polyhalite (whence its name), which occurs upon drusy sylvine. The mineral bears a close resemblance in appearance to gypsum, is perfectly pellucid and colorless, crystallizing in slender tabular forms, which, though of marked monoclinic habit, proves to be orthorhombic upon optical examination.

The new mineral is a hydrous sulphate of lime and potassa, having the formula $CaSO_4$, Ka_2SO_4, H_2O, a constitution which, though analogous to that of polyhalite, is distinguished from it by the almost total absence of magnesia sulphate, of which the latter mineral contains about 20 per cent. The crystals of the syngenite are characterized by a great richness of surfaces; its hardness is 2·5, and sp. grav., 2·73.

Mr. J. C. Trautwine informs the writer that he has found aurichalcite (a hydrous carbonate of zinc and copper), amongst the zinc ores of Sussex County, New Jersey. It is stellate, and of precisely the same light, bluish-green color and pearly lustre as that from Campiglia, in Tuscany. It occurs on white dolomite. As a new locality for the occurrence of a somewhat rare mineral, the observation is of interest.

We have also to record the discovery, within the past month, of an immense deposit, apparently in true vein form, of corundum, at Unionville, in Chester County, Pennsylvania. The amount of this valuable mineral thus far uncovered upon the surface, and in sight, is pronounced to be of itself sufficient to warrant the assertion that the deposit is the most extensive in the country, if not in the world. A more detailed description of this interesting occurrence is at present in course of preparation for the Journal, and will appear in our February issue.

Editorial Correspondence.

Combustion in Compressed Air.

Editor of the Journal of the Franklin Institute:

Sir,—In my report, Oct., 1870, on the bridge at St. Louis, I stated that the combustion of candles in the caisson under the action of compressed air was much more rapid than in the normal atmosphere, and that at the depth of 100 feet below the surface of the water they were consumed in about three-fifths of the time required in the open air.

Soon after this report was published, you drew my attention, by a private letter, to the fact that Dr. Frankland had previously made experiments, the results of which were at variance with my statement; and, in consequence of this disagreement, you thought it important, during the continuance of the work in such unusual depths, that careful investigations of this subject should be made by me. Acting upon your suggestion, I submitted your letter to my Chief Assistant, Col. Henry Flad, C. E., with request to make the experiments very carefully himself, and in the manner which was also suggested by you. This he did, and the results proved that my statement in the report referred to was incorrect.

Impressed with the belief that the combustion was more rapid in consequence of the large quantities of smoke emitted by the flame in the compressed air, I had charged one of my assistant engineers, who was on duty in the air-chamber, to note the difference in the rate of combustion under two conditions. My statement in the report was the result of his inaccurate report to me. Not deeming that any question of scientific interest was involved, he had simply noted the average difference between the duration of candles quietly burning in the open air shafts and those in the air-chamber, which were subjected to almost constant motion from being carried about by the workmen, or by being frequently moved from place to place, in consequence of which much of their substance was liable to flow away without entering the wick.

It has been my intention to publish the results of Col. Flad's experiments in some future report on the bridge, but I deem it my duty to delay this correction of my misstatement no longer, as I fear the failure to do so sooner has led others into error. In the account of the sinking of the piers of the South street bridge at Philadelphia, published in your last number, the writer asserts that candles burn twice as rapidly in the compressed air as in the open air. Although

this statement is made apparently on his own authority, I fear I am somewhat to blame for it, as he alludes in the paper to some of my experience at St. Louis, published in the report referred to. I am sure, at least, that it cannot be based upon his own experience, for the experiments of Dr. Frankland and Col Flad both show that combustion is not increased by the compression of the air in which it is occurring. The difficulty of extinguishing a flame is, however, greatly increased by increasing the pressure. I presume this is because the oxygen of the air is, by the abnormal pressure, brought into more intimate contact with the incandescent matter which is being consumed. Once in contact with it, however, the increased density of the air retards that rapid movement of the atoms of the gases about the flame, which results from combustion.

At the depth of 108½ feet, I blew out the flame of a candle thirteen times in rapid succession, and each time, excepting the last, it it reappeared at the wick. On a subsequent occasion, a few feet deeper, and under a pressure of about 52 lbs. per square inch, I blew out the flame of another 32 times consecutively, with the same result. This phenomenon was first observed by me at the depth of 80 feet.

Very respectfully,

JAS. B. EADS.

THE CLEVELAND LAKE TUNNEL.

CLEVELAND, OHIO, *October*, 1872.

Editor of the Journal of the Franklin Institute:

DEAR SIR,—In reply to your inquiry concerning the present condition of work upon the Cleveland lake tunnel, I beg to state that four thousand feet from the shore shaft were completed in 1871, April 19th, when water came in and prevented us from continuing our work at that end. Then we commenced to work from the lake shaft, August 1st, and continued till the 1st of December, when we were again compelled to stop on account of soft clay until we obtained a shield and hydraulic press. Nothing, however, was done the remainder of the winter, as the ice prevented us from reaching the crib. But in April we again continued our work, and, getting through the soft clay, we removed the shield and hydraulic press, and are now accomplishing about seventy feet a week. About nine hundred and fifty feet from the lake shaft is completed, but there is still sixteen hundred and fifty feet to be finished. Should fortune favor us, the tunnel will be completed in February.

Yours truly, JOSEPH MCDONELL.

Civil and Mechanical Engineering.

HORSE-POWER OF STEAM-BOILERS.

A Report of Remarks made at the October (1872) *Meeting of The Franklin Institute, of Philadelphia, upon the Method of Determining the Horse-power of Steam-boilers.*

[From the Phonographic Notes of J. I. Gilbert.]

After the usual preliminary business, the President (Mr. Coleman Sellers in the Chair) remarked:

This evening has been set apart specially for the consideration of the Committee Report upon the Investigation into the Method of Determining the Horse-power of Steam-boilers. Is it the wish of the meeting that the Report of the Committee shall be read?

An affirmative response being given, the Secretary of the Institute, Dr. W. H. Wahl, proceeded to read the Preliminary Report and subsequent Report in regard to the amount of heating surface required.*

The PRESIDENT.—The meeting has heard the Report of the Committee. Is there any motion in reference to it, to be brought before the Institute?

MR. EDWARD BROWN (Chairman of the Committee).—The report, in the form in which it has been submitted, does not present, specifically, any proposition by the adoption or rejection of which the sense of the meeting may be ascertained upon the subject referred to, the Committee having confined themselves to presenting simply all the information acquired by them and of use to the engineers and others interested in the subject. In order to bring the matter more directly before the public, and to give it that force and interest which its importance demands, it would, perhaps, be better that this Institute should take some action upon the Report by resolution. We have no power, of course, to pass any law on the subject, but upon such a question the sense of this Institute, as expressed by resolution, would have a large influence in assisting to create a general custom, which custom would, if continued, assume all the force and authority of law.

I will read the resolution and then submit it, when it will be within the province of the meeting to amend, accept or reject it, as they

* See Journal of Franklin Institute, Vol. lxii.

please. [Reading.] "The Report of the Committee on the Horse-power of Steam-boilers having been read and discussed, this Institute recommends the following for adoption by engineers:

"1. That the rating of steam-boilers be based upon the evaporation of a cubic foot of water into steam from and at 212 degrees, and at a specified rate of economy per lb. of anthracite coal consumed, or an equivalent amount of combustible; the trial to be made under the usual conditions of practice, such as the natural or artificial draught and pressure of steam for which the boiler is designed.

"2. That the term 'horse-power,' as applied to steam-boilers, be discontinued. When used, however, it should signify an evaporative capacity equal to that above named, and at an average economy; which average economy for stationery boilers is assumed to be 9 lbs. of water per lb. of coal consumed, at which rate, as near as practicable, the test should be made."

Mr. Wm. Barnet Levan moved to amend the resolution by substituting in lieu of "one cubic foot" the words "1000 cubic inches."

Mr. Robt. Briggs (a member of the Committee) said:

The proposition just read, and which now comes before the Institute for the first time, should be understood to be distinct from and independent of the Report of the Committee; and its author, I suppose, so intended it. It proposes that the Institute, as a body, should state its opinion as to what should be the established nominal horse-power of the boiler. Such a course would certainly be somewhat novel, inasmuch as it has not generally been the practice of the Institute, after the report of a committee has been made, to make any recommendation concerning the subject matter of the report. I think it questionable whether we ought now to depart from our settled custom in this particular.

In regard to the report itself I have a word to say. The Committee, in their investigation, went so far as to inquire into the customs and practices of engineers of other countries, and in the conclusions arrived at we were in accord up to a certain point, at which I felt constrained to differ with my colleagues, in their giving, as I thought, undue prominence to some imperfect experiments with boilers under circumstances most favorable to the production of power and of themselves least favorable for permanence and continued existence. The result was that in the final report of the Committee a nominal or deducible amount of surface is given to correspond to the actual evaporation in practice of a cubic foot of water.

As stated by the Committee, the "horse-power of a boiler" was originally understood as applying to the horse-power of the boiler and engine combined, these being taken as parts of a whole and as forming one machine. In comparing the motive power of steam, as applied through steam engines, with a certain number of horse-power, very careful examinations were made by James Watt, and before him by Smeaton, as to the power actually exerted by the strongest horses in England. What was the result as a mechanical performance as compared with horse-work? The horse performed a labor equivalent to the raising of 33,000 lbs. one foot high in one minute, and the boiler (or engine) in effecting a corresponding labor continuously for one hour would evaporate one cubic foot of water, with the combustion of nine to twelve lbs. of coal. But in time the functions of the boiler and the engine became more independent of each other and more distinctly defined, the former being regarded simply as a means of exposing the water to the heat of the fuel, while the engine, as a piece of machinery, underwent a variety of modifications or improvements by which from a given amount of steam a much greater degree of power was attained than had been thought possible. Consequently, in place of consuming all the steam that could be evolved from the evaporation of a cubic foot of water in producing a horse-power in one hour, the same power is now acquired by an evaporation of less than two-ninths of a cubic foot of water. The saving in the consumption of coal has been such that we have now reduced the amount from nine or ten lbs. of coal to less than two lbs. in our very best engines. The result has been, as I have said, that the engine has become as a machine of itself, independent from the boiler. Our engines in ordinary usage in this city—the ordinary engine of commerce, the high-pressure engine of to-day—taken on the average, will consume from four to five lbs. of coal to the horse-power, viz.: taking the productive capacity of the engine on the one hand, and the consumption of fuel as producing that power. The better class of engines, such as an expanding compound engine, as placed on our best marine steamers, goes down as low as two lbs. The older engines that Hornblower built in Watt's time went down to three lbs., and were a very great improvement on Watt's own practice, but, unfortunately, Hornblower was driven out of the market by Watt, and in the expansive engine we are merely following one of Hornblower's original propositions, with almost exactly the same details of construction that were first proposed by him. All the writers of eminence who have followed

since the time of Watt have been troubled with this divergency between the boiler and the engine; and, to-day, not only are the writers in difficulty about it, but those who make patent boilers are specially in difficulty on the subject, for they are desirous of having their boilers sold and tested upon the basis of the very best engine possible, instead of being sold and rated upon the basis of the original practice in engine construction.

From all the reports of prominent boiler makers—Armstrong and others who have written on the subject of boiler making—it has been customary and regular to consider the evaporation of this cubic foot as the horse-power of the boiler. Mr. Pohl, who is an eminent authority on the subject, objects to the evaporation of the cubic foot of water. He does not object to it of itself, but he objects to it as a unit (as this resolution objects to it), because of the difficulties of reducing the quantity of heat to the evaporation of the cubic foot of water. When we consider the cubic foot of water as a unit, we are obliged to accompany it with several conditions, viz.: 1st. At what temperature is that water to be taken? 2d. At what temperature is the water to be evaporated? In practice, we take the water into our boilers from a temperature of 40 degrees to a temperature of 120 degrees, and, in the general practice, perhaps in this city, we evaporate it from a temperature of about 60 degrees to a temperature of about 360 degrees. Now in such a case more heat of course is required than would be required if the water was pumped into the boiler at 212°, and the water was then evaporated at the constant temperature of 212°. This rectification of the unit, of taking the evaporation of a cubic foot of water from and at a temperature of 212°, was one that was followed subsequent to Watt's time, and has been generally followed in England, and it is the one followed by this Committee. Mr. Pohl, recognizing the difficulty, suggests that in the place of the evaporation of a cubic foot of water as a unit we should use the units of heat absolutely given out by the boiler.

Mr. Rankin, on the other hand, makes some very careful deductions. He has a carefully prepared table to enable any person to reduce readily the evaporative effects of the boiler from one temperature of water to another temperature of steam—to reduce it readily to see what its proper evaporative effect would be from and at 212°.

Now, it seems to me we had better remain just where we were with regard to the horse-power of a boiler; that we cannot, by any possibility, induce people to give up the words "horse-power," as applied

to boiler capacity, because they are too thoroughly interwoven in our nomenclature, too well known by mechanics, and there are too many people interested in preserving them; and that any attempt to abolish the term absolutely would prove almost an impossibility.

But it seems further that we should recognize, with the Committee, that there is no necessary connection, whatever, between the nominal horse-power of a boiler and the actual or nominal horse-power of the engine. I cannot see any reason for changing the amount of evaporative effect, to be rated as a horse-power from 1728 cubic inches to 1000 cubic inches, particularly as in so doing we are obliged to set up a new standard, diverse from any known elsewhere, or that is practically followed throughout the world, and that we shall be under the necessity of establishing a new basis, which, after all, is purely arbitrary. I think we should leave those who wish to rate their boilers upon the basis of a specific horse-power perfectly free so to rate them and to advertise them accordingly. Do not let us make a different basis from that which has heretofore been generally recognized.

Mr. Edward Brown.—With the permission of the Institute, I will recapitulate the points of the resolution I have offered, and give some of the reasons that have induced me to offer it.

Nearly two years ago I was called upon, with other engineers, to estimate the horse-power of a boiler that had been sold, and, in the inquiries we made on the point, my colleagues and myself became aware that so far from there being any fixed standard in the city, there was much diversity of opinion on the subject. Whilst some purchasers of boilers expected to get the indicated horse-power from the engine, others expected to get the cubic foot of water; which was two or three times as much. There where others, also, makers of steam-boilers, who expected to give half a cubic foot, thirty lbs. Seeing that there was such a difference of opinion amongst engineers, I thought the time had arrived when some definite basis should be established, especially when many purchasers of boilers had, at much expense to themselves in loss of time and the stoppage of their machinery, taken the question into the courts for legal adjudication, and that much difficulty in the future, from this cause, might be avoided if a definite basis could be promptly settled. I therefore moved for a committee to take the matter into consideration. The result of the labors of that Committee, extending over a period of a year and a half, we have just heard in the report which they have submitted.

That this length of time was necessary for the preparation of an intelligent report will be apparent from the fact that we had to correspond a great deal with engineers in Great Britain on the subject; and, as they use as many steam-boilers there as we do here, and as the terms used in the weights and measures are mainly identical, it was thought advisable that whatever we decided upon should be satisfactory to them, consequently the corresponding across and the necessary comparison of calculations took a long time, but we definitely settled the question among ourselves.

Now, in regard to the resolution, the first clause is a recommendation that the rating of the boilers "be based upon the evaporation of a cubic foot of water into steam." Now "the cubic foot" is far more easily measured than "the thousand inches," independent of the fact of its having always been the basis for the horse-power. It is an easy matter for steam-boiler users, with a two foot rule only, to measure the quantity of water in the tank, and no further calculation is required, other than that by the formula given, to reduce the amount to the standard of 212 degrees. When we use the term "*into steam*," of course we mean "dry steam," not water carried over with the steam. That may be determined in various ways.

"And at a specified rate of economy per lb. of anthracite coal consumed or an equivalent amount of combustible."

A purchaser wants a boiler that will give out, we will say, 100 horse-power in his factory. He goes to the boiler-maker and says, "I want a boiler that will give out 100 horse-power in the factory,—what could you supply me with?" The boiler-maker says, "I will give you a boiler that will evaporate sixty cubic feet per hour, and I judge from that and from the engine you have that it will give you the power you require; I will supply you with a boiler of sixty cubic feet capacity and at a certain rate of economy." He can say "at 9 lbs. of coal," or "8 lbs.," whichever he desires. That will be a definite amount which the purchaser will have before him, and he can then compare that estimate with that of any other boiler-maker, who may think that a boiler of a capacity of 50 cubic feet per hour would answer. "The trial to be made under the usual conditions of practice such as the natural or artificial draught." Now, it may be in the future that many boilers will be made with artificial draughts. These may possibly be found to give greater power, and therefore the advantage should be preserved of not limiting the nature of the draught, but testing the boilers in whichever way they may be found to produce the most power.

"And pressure of steam for which the boiler is designed."

I have been told that some boilers, that will work well when evaporating water at 212 degrees, will not work well at a pressure of 30 lbs., or perhaps 50 lbs. If that is the case, this second portion of the 1st clause, that the boiler be tested at the working pressure, would be necessary. It is said by some that boilers will prime at a 30 lb. pressure when they will not at 212 degrees. I am not sufficiently informed on the point to say whether this is or is not a fact; perhaps some of the engineers present will enlighten us during the evening as to whether boilers do prime in that way. I had supposed it was the extra amount of heat that was put into boilers that caused them to lift the water, in the same way that a pot boils over on the stove, or possibly from some peculiar condition of the water itself, and not on account of the steam being generated at a certain pressure.

"That the term 'horse-power,' as applied to steam-boilers, be discontinued."

Many engineers think it better that it should be discontinued. It is a misnomer, and conveys no definite idea of the power of the boiler. The word has become so common, however, that I do not think we can eliminate it from common use or do away with it entirely; therefore, "Whenever used it should signify an evaporative capacity equal to that above named, and at an average economy, which average economy for stationery boilers is assumed to be 9 lbs. of water per lb. of coal consumed."

Now you can see that if we do not put any economy down, any fixed rate of consumption, the power of the boiler may vary considerably. For instance, in the experiment made by Mr. Isherwood, in the case of the steamer San Jacinto, that gentleman took the boiler and evaporated under natural draught and then again under forced draught, and there was a difference on the same boiler in the amount of heating surface required to evaporate a cubic foot, in the ratio of 10 to 18. In other words, by a change in economy a 10-horse boiler is changed into an 18-horse boiler. Therefore, unless we make some definite amount of economy, we still have a range in the evaporation of from 10 to 18 in the same boiler, and the basis would not be sufficiently definite; but even that would be better than the present practice, under which it varies from one to two hundred per cent. We have not now even a basis to go upon at all; the *quantity of water* is not even decided upon, independent of all these conditions which

may affect the amount evaporated. I propose that we reduce the conditions, *as near as possible*, to a fixed basis. We say, "assuming 9 lbs. of water for each lb. of coal consumed."

Some of the English engineers have thought that a little high. I do not think it is; neither do many American engineers. I have received from some English engineers their opinions as to what the basis for the rating of steam-boilers should be and what would be the average economy. I will refer here to the proposition of R. B. Longridge, of Manchester, Eng., whose experience in boiler testing probably equals that of any other engineer in the business. He proposes 7 to 7½ lbs. at 62 degrees to 212 degrees. This equals 8·6 lbs. from and at 212 degrees. Eastons & Anderson, London, propose 8 lbs. at 62 degrees to 212 degrees. This equals 9·2 lbs. from 212 degrees. The navy test in the United States is an economy of 7·8 lbs. from 100 degrees to steam at 30 lbs. This equals 8·86 lbs. from and at 212 degrees. The average of these three methods is 8·88 lbs. Mr. Thurston, of Hoboken, who examined the boilers at the New York Institute Fair, says 9 lbs. is low enough. I take from Bournes' Catechism a trial of thirty different kinds of English coal, and the average is 8·66. So you see that the economy of 9 lbs., assumed by the Committee, is very near the average amount.

Professor Robt. E. Rogers said:—Mr. President, I desire, with the members of the Institute at large, to express most cordially my thanks to the Committee, who have so laboriously and through so long a time devoted themselves to this most important investigation. In doing this, however, sir, there are some suggestions coming up in my mind which, if they should prevail with others present, would admonish us, I think, to pause a little before we commit the Franklin Institute upon a question which has so divided and agitated the engineering world up to the present day. It may be said that the action here contemplated is intended to be advisory only; but, sir, we are proud of the Franklin Institute as being truthful, as being cautious and careful and thorough in its investigations and in never having given her endorsement to anything that was not really standard. Therefore, sir, since there are some points which at least might be the subject of criticism, in connection with this report—while, I am sure, my good friends on this Committee will understand fully my own personal feelings toward them, that it is no spirit of captious criticism that prompts me to utter these suggestions—I think it would be well for us to look into one or two of them before we move.

In the first place, if I understand it, this is to be not simply a scientific settlement of a question which is to be handled hereafter by experts in the decision of questions coming to them perhaps from the courts, but it is to be of practical utility. It is to be dealt with by the engineer in his ordinary avocation, and by the boiler builder, who, in many instances, unfortunately has not the algebra to aid him in his equations, and cannot have at his hand those close and accurate investigations the results of which are comprised in the carrying out of this Report.

Now, let me ask what is meant on the 3d page of the Report, where it is said there shall be nine lbs. of water evaporated by one lb. of coal over and above the ashes. Are the coals analyzed? or is the ash to be weighed in every experiment when one man sells a boiler to another? This passage in the Report should at least be interpreted before we carried the resolution.

Again; the words "from and at 212" frequently occur in the Report; they are commonly used in engineering language, but I ask any boiler maker not extensively engaged in business what he would understand by the terms "from and at 212?" I understand their meaning to be that the water being pumped into the boiler at 212°, or calculated as if it were at 212°, shall continue to be boiled away under the temperature of 212°. Therefore, to avoid confusion, I would suggest the substitution of a sentence conveying this idea, to wit: the pumping of water into the boiler at the temperature of 212°, or calculated at that, and then the water evaporated under the pressure of 15 lbs. There is then no confusion. And here let me ask, what boiler maker, by inserting a thermometer in a boiler, can tell that the temperature is at 212°? A special device is requisite for that purpose as a substitute for the pressure valve or guage. It would sound somewhat novel for a boiler maker to speak of the temperature of the water at which *he* is generating steam as forty, fifty, sixty or ninety pounds; his invariable method of ascertaining this is to look at his guage. Therefore, to put this matter on a practical footing, it is indispensable that the language made use of be free from all ambiguity and the instrumentalities referred to be available, as in this way alone can it be of value or interest to either the maker or the receiver of the boiler.

Again; to estimate the amount of water boiled, as it is termed, is of no earthly value in my view, unless you are sure that you separate the steam from the water carried over as spray or in the process of

foaming. Therefore the boiler-maker must have an instrument which will filter out, so to speak, the free water eliminated from the dry steam, by which he may be able to compute what the boiler is really doing in good healthy steam-making. But, as every boiler-maker and engine user in this Institute well knows, a boiler will operate very differently when the water is boiled at a temperature of 212° from what it will when the water is boiled at a temperature which will give 60 lbs. pressure. We know perfectly well that in some boilers the moment the valve opens and allows a full supply of steam to the engine there is a relief of pressure, and up rises the water; and whether that condition of things takes place more or less will depend frequently upon the peculiar construction of the boiler. Therefore, sir, I think the suggestion ought to be at least introduced into the Report, that each boiler should be tested at the particular working pressure under which it is intended to be used. If the boiler is actually tested at the working pressure designed by the user, then that particular difficulty will be obviated; but the question comes back again: If, "at 212°," we provide the means simply to estimate the amount of water carried over we ought certainly to provide similar means when the pressure is greater.

Now, my difficulty, Mr. President, is not that this Report is not admirable, that it does not fulfill all the requirements of a scientific report; my difficulty is that I do not think it meets the requirements of the case in a practical way. I do not think it is quite practical enough, though I have come to this opinion very reluctantly. It is high science, and I yield to no one in this community in my appreciation of and respect for high science; no one more than myself could deplore whatever would have a tendency to ignore or depreciate thorough science, but I do want to see that science associated with something that is positively practical, and can be made available to the common engineer and to the ordinary boiler-maker as well as to the expert. [Applause.]

Mr. Robt. Briggs, in reply to Prof. Rogers, remarked that the expression "from and at 212°," had been used by Rankin and other writers on steam engines. Its meaning was not by any means that a boiler shall be tested at 212 degrees, but the language was made use of for the purpose of using the 967 units of heat. It was only for the purpose of making this evaporation of a cubic foot of water a constant, tangible unit.

Prof. Rogers expressed the opinion that his remark had been mis-

apprehended by his friend (Mr. Briggs). He had not intended to say that the expression, "from and at 212 degrees," was not a true representative of the amount of caloric, nor that it was not perfectly scientific. The idea he had sought to convey was simply that the means by which the temperature of 212 degrees was to be ascertained were not practicable, as the boiler-maker would be required to insert his thermometer into the boiler to find the fact. All that Mr. Rankin had said was perfectly true, as all present well knew, but the question was not one as to the thermometer, but as to the only instrument we had to work with, the pressure gauge.

Mr. JOHN WISE suggested the propriety of making the standard value of horse-power of the boiler to correspond to a certain amount of air supplied through a blower at a given pressure in a certain space of time, which would give a fair and invariable rule of action by which to find the horse-power value of the boiler.

The PRESIDENT:—The present position of the business before the Institute seems to be simply this: The first resolution, as offered, contemplates certain action on the part of the Institute, whether or not they shall endeavor to establish any rule. It then lays down certain rules. An amendment to that resolution has been offered. It is proper in all cases to proceed with the amendment first; but I think you will all agree with me that the better course would be for us to determine first whether we shall endeavor to establish any rule, and then afterwards consider the contingencies of the case. Therefore, I think there will be no objection to the consideration of the main question as first in order, viz., whether the Institute deem it advisable to endeavor to establish a rule for rating the power of boilers. I think that expresses the purport of your resolution, Mr. Brown—does it not?

Mr. EDW. BROWN.—Yes, sir; that is the first thing to be considered.

Mr. THOS. J. LOVEGROVE said:—Mr. President, this is a grave and important question. I do not think this worthy and impartial Institute intends to do the boiler-maker the great injustice of asking him to build a boiler that will evaporate a cubic foot of water for a horse-power per hour, when the evaporation of a cubic foot of water and its proper condensation is nearer three times that amount.

Prof. ROGERS.—If I may be permitted, Mr. President, to rise once more, I would suggest, if it were in order, the propriety of a resolution somewhat to this effect: That the report of the Committee be

received and entered on the minutes of the Franklin Institute; and that the Committee, if the members will consent to do so, be continued with a view to the attainment of the object which we all have at heart. That object, I think, has not yet been accomplished, but something—nay, much—toward its accomplishment has been achieved. May I ask, would it be in order to offer a substitute for the pending resolution?

The PRESIDENT.—The Report of the Committee has already been accepted, and the Committee has been discharged.

Prof. ROGERS.—Well, I would ask, sir, that that Committee (if its members have no objection) be revived and requested, with our thanks for their labors heretofore, to continue the investigations in which they have so far advanced.

Mr. CHAS. S. CLOSE.—I understand the motion of the gentlemen (Prof. Rogers) to be to strike out all after the word "Resolved" in the resolution, and insert as he has indicated.

Prof. ROGERS.—Yes, sir.

Mr. CLOSE.—I second the motion.

The PRESIDENT.—It would be necessary for us, in proceeding regularly and in order, to take some action on the amendment that is already pending; otherwise the position of the question may become complicated.

Mr. CLOSE.—My understanding was that a motion to strike out and insert a substitute for the original resolution carried with it the amendment.

Mr. WM. BARNET LEVAN.—Mr. President, before action is taken, will you please read the definition (in writing), upon your table, in regard to a cubic inch of water, evaporated under the ordinary atmospheric pressure, as converted into a cubic foot of steam?

[The President read as follows from Dr. Ure's Encyclopedia:]

"A cubic inch of water, evaporated under the atmospheric pressure, gives a mechanical force equal to that which would raise a ton weight one foot high."

The following are the effects produced at 212 degrees under the above-named pressure. Careful experiments have determined, within very small limits of error, the following facts: Steam, under pressure of 35 pounds per square inch and at the temperature of 261 degrees, exerts a force equal to a ton weight raised one foot. Under the pressure of 15 lbs., and at the temperature of 213 degrees, it is 2,086 pounds, or about seven per cent. less; and under 70 pounds at

306 degrees, it is 2,382 pounds, or nearly six and a half per cent. more than a ton raised one foot. It is sufficient for all practical purposes to assume that each cubic inch evaporated, whatever be the pressure, develops a gross mechanical effort equivalent to a ton weight raised one foot.

As a given power is produced by a given rate of evaporation, to determine this the following rules are applicable. To produce the force expressed by one-horse power, the evaporation per minute must develop a mechanical force equal to 33,000 pounds, or about fifteen tons raised one foot high. Fifteen cubic inches of water would accordingly produce this effect, which, without expansion, would be equivalent to 900 cubic inches per hour. To find, therefore, the gross power developed by a boiler, it would be only necessary to divide the number of cubic inches of water evaporated per hour by 900.

Prof. ROGERS.—Mr. President, I would modify my motion so that it may read: "Strike out all after the word 'Resolved' and insert simply 'that it is the wish of the Institute that the Committee be continued.'"

Mr. EDW. BROWN.—Mr. President, though desirous of a settlement of the question, I have no wish to urge that this resolution be adopted by the Institute; I would defer entirely in the matter to the pleasure of the meeting, because I would be sorry, as the gentleman (Prof. Rogers) says, that the Institute should commit itself to any measure about which its members have any doubts.

My purpose was simply to call attention to the great uncertainty which surrounded this question of boiler capacity, the variation of the basis for measurement extending from one to two hundred per cent. The question having now been brought prominently before the engineers and boiler-makers of this city, the increased interest which will be felt in it by those who make and use steam boilers, will have its advantage in causing parties contracting by the term horse-power, to have some understanding at the time as to the definition of the term. It is personally immaterial to me whether the resolution is adopted or rejected.

A vote being taken, the question was decided in favor of the modified amendment submitted by Prof. Rogers, expressing the sense of the Institute in favor of the revival and continuance of the Committee. The resolution, as amended, was adopted.

Mr. S. LLOYD WIEGAND remarked that, as the Committee was at present constituted, no one of its members, so far as he knew, was

interested in the more recent types of boilers, to which some allusion had been made in the discussion, and which were referred to in the introductory resolution under which the investigation was inaugurated. There seemed to be a statement of views here reflecting somewhat on the makers of modern boilers, of new types of boilers, and the impression had got abroad that these makers would like to sell boilers upon the representation that they had more power than they actually possessed. To remove the *ex-parte* appearance of the Committee, and give all parties an opportunity for representation upon the Committee, Mr. Wiegand submitted a resolution that the Committee be enlarged by the addition of three members interested in, or having cognizance of, the more modern types of boilers, the new appointments to be made by the President of the Institute before the next meeting.

Mr. BRIGGS.—Mr. President, I would be exceedingly gratified to resign from the Committee, so that my place may be filled by any one having more interest than myself in a particular type of boiler.

The PRESIDENT (aside).—I am sure the Institute would regret to have Mr. Briggs retire from the Committee.

PROF. ROGERS.—Mr. President, perhaps it is due to myself that I should say my remarks had no reference to any member constituting the Committee, and I should be extremely sorry if Mr. Briggs, or any other gentleman of the Committee thought they were prompted by any spirit of that kind. On the contrary, I look upon that Committee as eminently qualified, by their scientific and practical knowledge combined, to throw light upon this most difficult question. If Mr. Wiegand's motion is carried, I trust that Mr. Briggs will not relinquish that duty which he is now performing so satisfactorily to us all.

MR. BRIGGS then seconded the resolution to enlarge the Committee; and a vote being taken, the resolution carried.

The Institute then proceeded to other business.

Echoes in Public Halls.—It is asserted that by stretching wires at some height across buildings with lofty ceilings, the difficulty frequently experienced from the presence of the echo will be completely obviated. The wires are explained to act in breaking up the sound-waves and preventing their reflection.

BESSEMER MACHINERY.

A Lecture delivered before the Students of the Stevens Institute of Technology by ALEX. L. HOLLEY, C. E.

(Continued from page 265.)

Let us now briefly consider some of the details of hydraulic machinery.

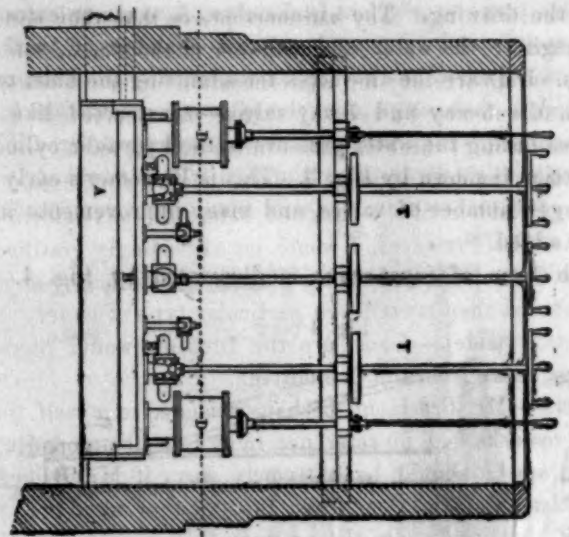


Fig. 1.

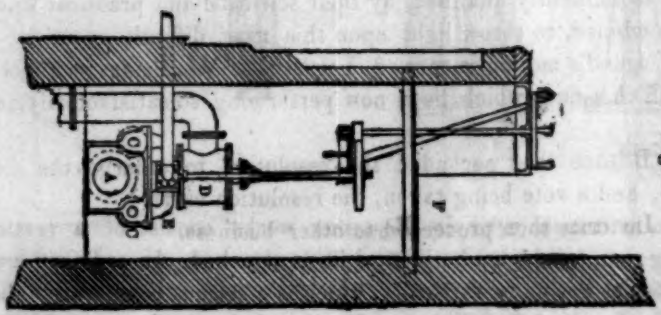


Fig. 2.

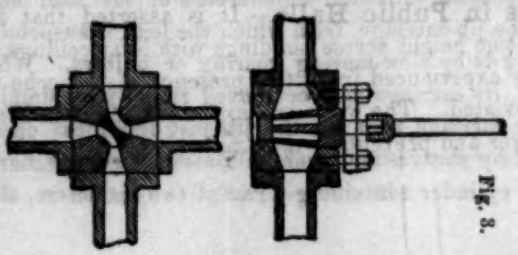


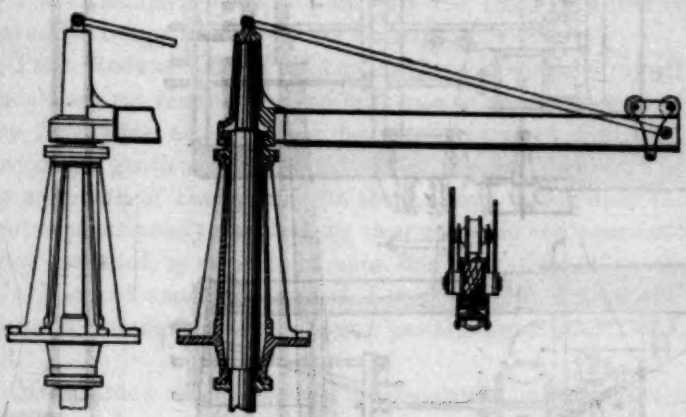
Fig. 3.

Drawn by G. K. Dickinson, Class of 1875, Stevens Institute of Technology

The regulator before referred to (Fig. 2) is a raised platform, F, over the air and water distributing apparatus, standing upon which workmen can observe and regulate all the motions of the vessels and cranes. The necessity of concentrating these operations at a point out of reach of the working heats of the vessels, and the flying splashes in case of accident, will be obvious. The construction is explained by the drawing. The air-chamber, A, communicates with the blowing-engine; the water and exhaust chambers, C, with the pressure-pump. D D are the air-valves for admitting the blast to the vessels; E E, the 3-way and 4-way valves—constructed like gas-cocks—for distributing the water-pressure to the hydraulic cylinders. Their construction is shown by Fig. 3. This is Bessemer's early regulator. A larger number of valves, and many improvements in detail have been added.

The English form of *ingot-crane* is illustrated by Fig. 4. All

Fig. 4

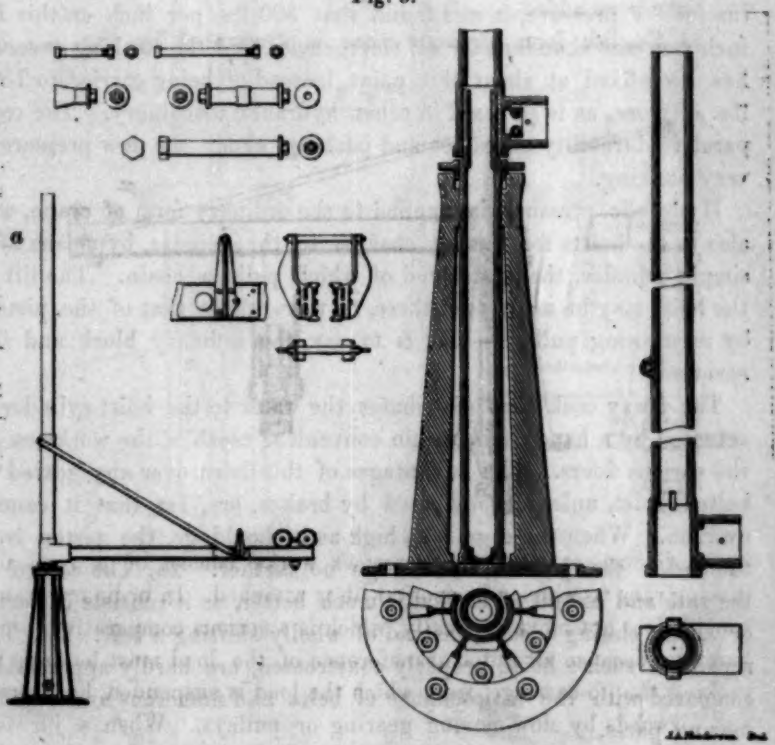


hydraulic cranes used in Bessemer works consist of a vertically moving ram, to which a horizontal jib is attached. In ordinary cranes the jib does not move vertically, which is a serious comparative disadvantage, because all radial transference of the load must be done by racking the jib-carriage, from which the load is suspended, backwards and forwards by slow-moving gearing or pulleys. When a jib *rises and falls*, its carriage may be moved radially by simply pushing the load; the carriage runs on the jib just like a car on a railway, unhampered by sheaves and chains. Bessemer's crane, here shown, consists of a cylinder containing a ram of two diameters, the smaller end

passing through a bottom stuffing-box, and the larger through an upper stuffing-box. To the upper end the jib is attached. The difference in cross-sectional area between the two ends of the ram is the area acted upon by the water to lift it. The lateral strain of the overhanging jib, on the upper end of the ram, is very great, requiring excessive strength; and its friction in the stuffing-box is so severe that the ram often chatters in rising, and the jib can only be turned in its orbit by means of the independent head revolving on rollers. The foundation must be hollow to get at the lower stuffing-box, and very solid and wide to keep the whole structure from tipping over.

The crane generally used in American works is shown by Fig. 5, and consists of a cylinder, open at the top only, and requiring

Fig. 5.



chiefly vertical support from the solid pier on which it rests. The ram passes through an upper stuffing-box, and through a top support

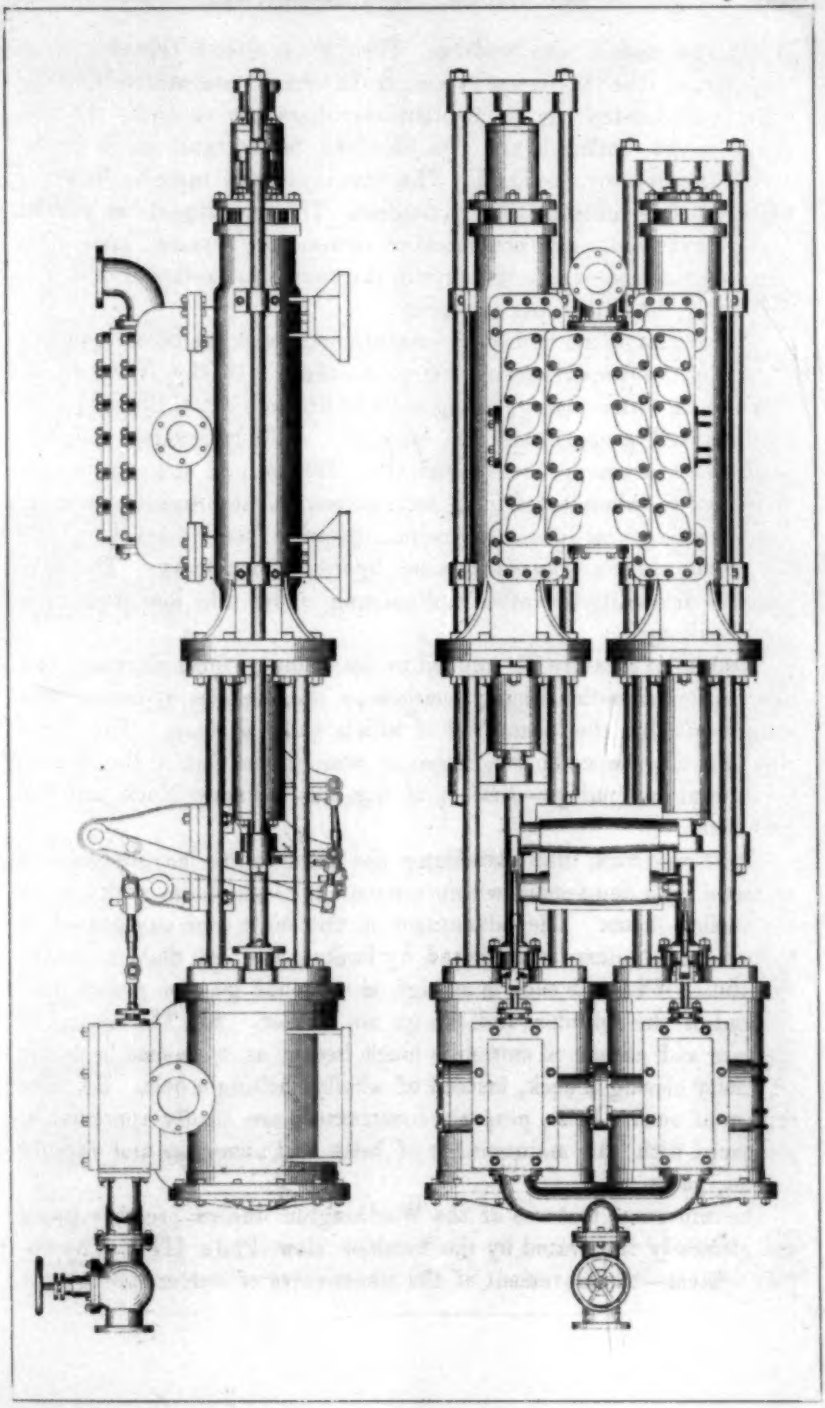
at *a* in the roof of the building. The jib is placed between these supports, so that the lateral strain on the ram is comparatively small. This is illustrated by the fact that no rollers are required; the ram turns in the stuffing-box. The jib of an 8-ton crane can be pulled round its orbit by one hand. The ram is stepped upon a column of water which is substantially frictionless. The top support has proved itself convenient, and economical of power and repairs; and, after counting the cost of the supports in the roof, this system of cranes is less costly than Bessemer's system.

The amount of the hydraulic pressure employed has been regulated chiefly by the proportions of the crane—that is to say, it was found that for an 8-ton crane, having a 10 ft. lift and 22 ft. jib, a 13-inch ram was well proportioned for strength. Adding frictions and fluctuations of pressure, it was found that 300 lbs. per inch on this 13-inch ram was abundant for all emergencies, and the working pressure has been fixed at about this point, instead of being carried to 1500 lbs. or more, as is so usual in other hydraulic machinery. The comparative durability of valves and packing under the low pressure is very striking.

Hydraulic pressure is applied to the ordinary form of crane, and also to the hoists for raising charges to the cupolas, by means of a simple cylinder, the piston-rod of which pulls a chain. The lift of the hoist may be made two, three, or more times that of the piston, by interposing pulleys—that is to say, the ordinary block and fall reversed.

The 4-way cock that distributes the water to the hoist-cylinder is actuated by a hand-chain within convenient reach of the workmen on the various floors. The advantages of this hoist over any geared or belted hoist, unless complicated by brakes, are, 1st, that it cannot overrun. When the cage is as high as it should go, the piston is at the end of the cylinder, and can go no farther. 2d. The control of the rate and extent of motion is much better, as it consists in partly or wholly closing a cock, instead of wholly shifting a belt. 3d. The repairs of such a hoist, properly constructed, are hardly appreciable, compared with the maintenance of belts and numerous and rapidly moving parts.

The important features of the Worthington duplex pressure pump are generally illustrated by the exterior view (Plate III). The duplex system—the movement of the steam-valve of one engine by the



WORTHINTON DUPLEX PRESSURE PUMP.

piston of the other engine—permits the water pistons to stop, momentarily, at the ends of their stroke, thus allowing the water-valves *time* to seat without slamming. This feature also causes remarkable uniformity of pressure, and the absence of the fly-wheel gives the pump all the other advantages of the Cornish engine.

Each water-engine, instead of being a cylinder bored from end to end and fitted with a piston, consists of two separate cylinders, bored in the throat only, and fitted with two plungers, connected together. A stuffing-box around a plunger is much more easily kept tight than the packing of a piston, especially when the latter has a variable stroke and tends to wear and enlarge the middle of the cylinder, particularly at the bottom, where sediment collects.

The water is pumped into an accumulator, consisting of a cylinder and weighted ram like those of a crane. When the cylinder is full, it nearly shuts off the steam from the pump by means of a lever and throttle-valve. This arrangement saves some steam, and prevents the pump from running too fast when several cranes happen to be started at once.

Safety-valves for pressure and feed pumps are abandoned, it having been found better to make the parts strong enough to resist the full force of the steam. When the water exit is shut off, the pump simply stops, under pressure.

The packings heretofore employed for the glands and pistons of hydraulic machinery have been leather cups, which are not very durable, and, when large, are quite costly.

The Martin packing, consisting of a roll of hemp tape forming a continuous ring, and covered with wire cloth on the wearing surface, has been lately adopted, with excellent results.

In the melting department some interesting and important changes have been made. The reverberatory furnace was, until recently, employed abroad for melting the principal charge, and is still used here and abroad for the spiegeleisen charge, because, as this is small and often has to be held for some time after melting, the flame of the reverberatory constantly playing over it prevents its chilling. The very oxidizable manganese in the spiegeleisen is also more affected by the blast of the cupola than by the comparatively neutral flame of the reverberatory.

In the older form of air furnace (Fig. 6), the flame and any free

air it may contain, are drawn from the fire-box A, along the roof of the furnace, and do not come into very direct contact with the metal lying at B; hence this form is best employed for melting the spiegeleisen. Fig. 7 shows a later form of furnace, which melts faster because the flame is thrown directly upon the metal lying at B; but it also oxidizes the metal more rapidly. It was first employed for melting the principal charge, but as it required three hours and two and a-half tons of coal to bring down five tons of iron, it was early abandoned here for the cupola, which melts a six ton charge in less than one hour with one ton of coal.

Fig. 6.

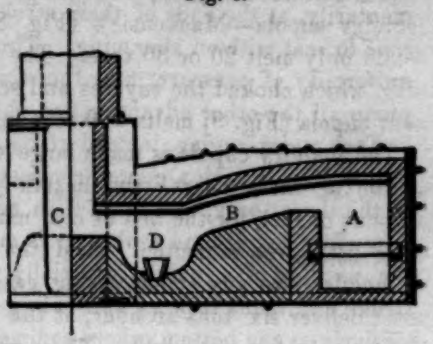


Fig. 7.

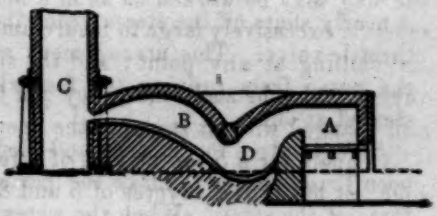


Fig. 8.

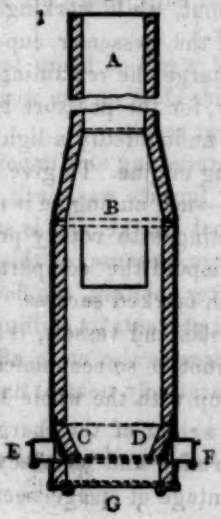
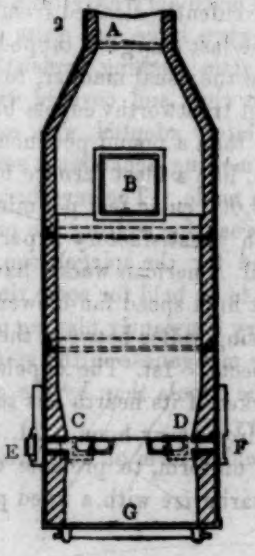


Fig. 9.



Adapting the cupola to the Bessemer manufacture has, however, required some costly experimenting. What was considered the best foundry cupola—Mackensie's (Fig. 8)—was first employed; but it would only melt 20 or 30 tons. The shallow bottom then filled with slag, which choked the tuyeres and scaffolded above them. The present cupola (Fig. 9) melts 100 tons in 18 to 20 hours.

The foundry cupola is made large enough to melt what is required in two or three hours; the hearth is left shallow to take the least amount of fuel, for the bed of coal must reach above the tuyeres, however little iron is melted. And the day's work is over before slag accumulates to any embarrassing extent. But the Bessemer cupola must deliver six tons an hour, at the highest attainable temperature, for a whole day and night. There must be a deep hearth or receptacle for slag under the tuyeres, and an upper tapping hole by which the slag may be worked off as in a blast furnace. The tuyere area must be excessively large to insure ample air admission in case of partial chilling at any point; and the size, shape and arrangement of tuyeres must be such that they can be conveniently got at, cleaned and changed without stopping the operation.

A cupola for a 5 ton plant is of 5 feet internal diameter and 14 feet high; it has 6 oval tuyeres of 5 and 8 inches diameter. The boshes, so prominent in the Mackensie cupola, are reduced to prevent scaffolding. The Mackensie annular tuyere, however valuable in foundry practice, is not adapted to long continued heats, because it cannot be conveniently cleaned from without, while working.

After the last charge is tapped out, the Bessemer cupola bottom is dropped, in the usual manner, to discharge the remaining *débris*.

The most trustworthy cupola blower, for the pressure here required —not less than a pound per inch—is undoubtedly a light reciprocating engine, like a blast furnace blowing engine. To give the required volume—6,000 cubic feet per minute—such an engine is rather costly. After much unsatisfactory experimenting with rotary pressure blowers, several American works have adopted the comparatively cheap Sturtevant high speed fan-blower, with marked success.

Interposing ladles between the cupolas and vessels, is important in many respects. 1st. The cupola cannot be so economically and regularly worked if its hearth has to fill up with the whole 12,000 pound charge of iron every hour. 2d. The weight of the charges should be somewhat uniform, to promote uniformity and accuracy of blowing, and to recarburize with a fixed percentage of spiegeleisen. This can

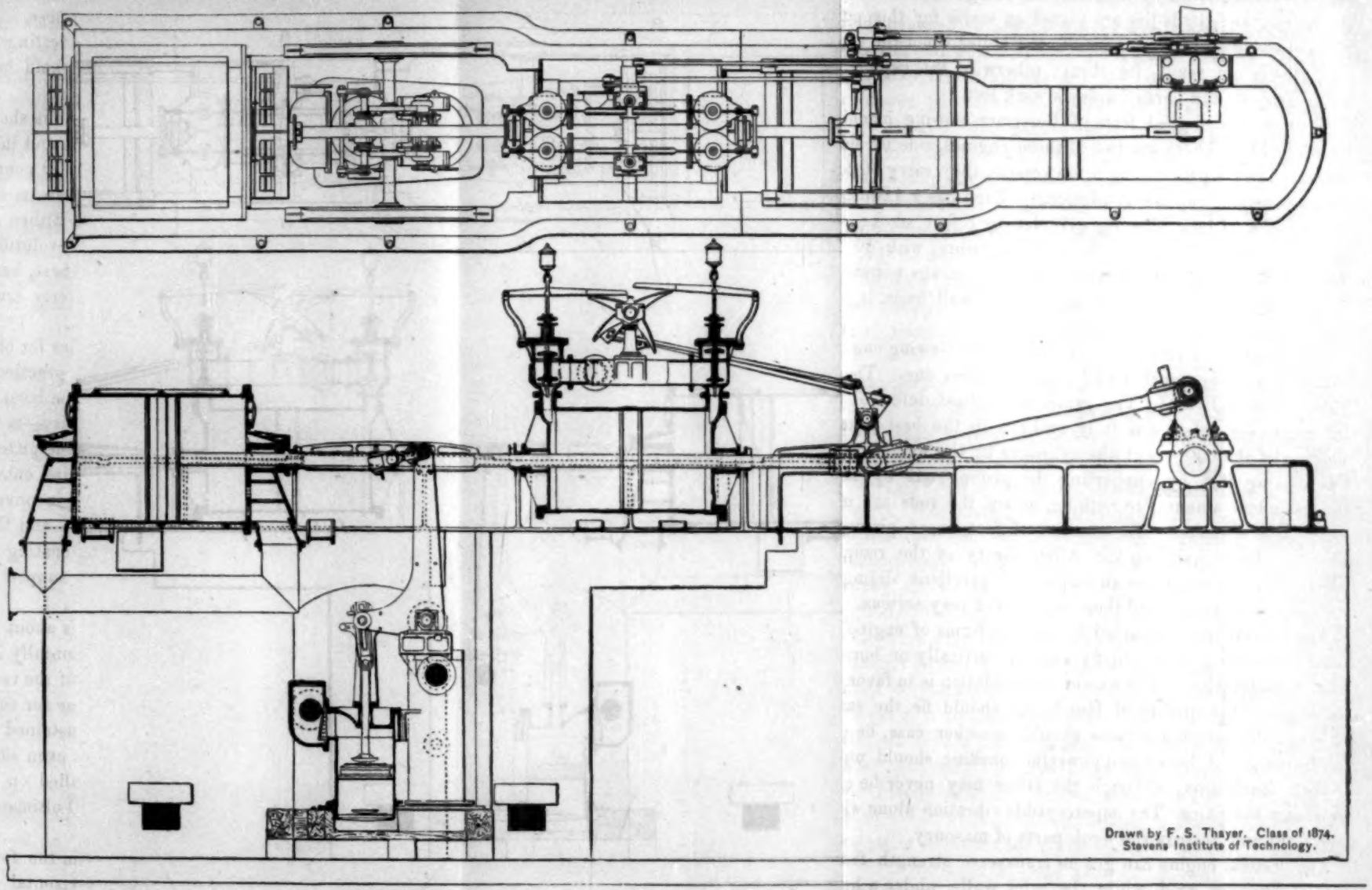
only be accomplished by weighing the charge between the cupola and the vessel; and the ladles are placed on scales for this purpose. 3d. Several charges are often run into the ladles when the converting department is not ready for them; otherwise the cupola would have to be dumped, and part of a day's work lost.

A common and good form of Bessemer blowing machine is shown by Plate IV. There are two of these engines, side by side and independent. For a pair of 5 to 6 ton vessels, they carry 60 to 70 pounds steam pressure, and are condensing. Each has a 42-inch steam cylinder and a 54-inch blowing cylinder by 5 feet stroke. Either engine will blow a charge at the usual pressure, with 40 revolutions. The old Mississippi river valve-motion is perhaps not the best, but it is certainly not the worst, in use; and if well built, is pretty trustworthy and economical of repairs.

The question of vertical *versus* horizontal blowing engines for blast furnaces and Bessemer works is still an open one. The practice is about equally divided. The grand theoretical defect of the horizontal engine—a defect not fully realized in the best practice—is the wearing of the bottoms of the cylinders by the weight of the pistons. Overcoming this by supporting the piston rods by slides outside the cylinders amounts to nothing, unless the rods are of inconveniently large diameter. As a matter of fact, broad pistons—and they are not objectionable on the Allen theory of the reciprocating fly wheel—are in themselves an ample and excellent sliding support on the cylinder bottom; and their wear is not very serious.

The cubical space occupied by the two forms of engine is about the same; whether it shall chiefly extend vertically or horizontally is a local consideration. The extent of foundation is in favor of the vertical engine; the quality of foundation should be the same for each, although the internal strains should, in either case, be sustained by the framing. A heavy and powerful machine should not even *sit on* a weak foundation, although the latter may never be called on for resistance to strains. The imperceptible vibration alone will ultimately ferret out and destroy the weak parts of masonry.

The vertical engine can get no transverse strength from the foundation, however good, while the solid walls, under a horizontal engine, reinforce the framing. The vertical engine is less conveniently got at for attendance and repairs, and this only by means of narrow and costly scaffolding; the horizontal engine is accessible in every part from the working floor.



Drawn by F. S. Thayer. Class of 1874.
Stevens Institute of Technology.

part from the working floor.

The tendency, however, is in favor of vertical engines, chiefly on the ground of their small floor space and foundations.

The best practice in Bessemer and rolling mills seems tending towards moderate steam pressures, say 50 pounds, and condensation. The former, whether theoretically economical of steam or not, is believed to promote the durability of boilers and enginery generally. Condensation certainly proves economical, and to an extent which even the theory would hardly seem to warrant, especially with moderate steam pressures.

TENSILE STRENGTH OF AMERICAN AND ENGLISH IRON AND STEEL.

A long series of experiments was recently made at the Camden and Amboy R. R. Repair Shops, Hoboken, N. J., by Mr. F. B. Stevens, in presence of a number of well known engineers and Prof. Thurston and his pupils, from the Stevens Institute of Technology.

The samples tested were from lots sent into market by various manufacturers, and may be considered to represent, in most cases, an average quality of the several grades.

Thirty-three experiments were made upon iron taken from the exploded steam-boiler of the ferry boat "Westfield." The following were the results:

Average breaking weight, lbs. per sq. inch,	41,653.
Highest " " " "	50,182.
Lowest " " " "	29,032.
Latter less than former, *per centum*,	42.
Average elongation, "	18.
Greatest " "	32.
Least " "	1·3.

Sixteen experiments were made upon high grade American boiler plate (Sligo), and resulted as follows:

Average breaking weight, lbs. per sq. inch,	54,123.
Highest " " " "	57,012.
Lowest " " " "	51,813.
Variation in *per centum* of highest,	9·1.

Fifteen experiments were made upon the best grades of American flange irons:

Average breaking weight, lbs. per sq. inch,	42,144.
Highest " " " "	53,277.
Lowest " " " "	(?) 33,003.
Variation in *per centum* of highest,	(?) 38.

Six experiments were made upon English Bessemer steel:

Average breaking weight, lbs. per sq. inch,	83,621.
Highest " " " "	86,580.
Lowest " " " "	74,509.
Variation in *per centum* of highest	14.

Five experiments were made upon the best English boiler plate (Lowmoor):

Average breaking weight, lbs. per sq. inch,	58,984.
Highest " " " "	64,000.
Lowest " " " "	55,300.
Variation in *per centum* of highest,	14.

Six experiments were made upon samples of tank iron, by three makers:

Average breaking weight, Maker No. 1,	43,831.
Highest " " " "	53,174.
Lowest " " " "	36,111.
Variation in *per centum* of highest,	32.
Average breaking weight, Maker No. 2,	42,011.
Highest " " " "	48,425.
Lowest " " " "	35,679.
Variation in *per centum* of highest,	28.
Average breaking weight, Maker No. 3,	41,249.
Highest " " " "	52,277.
Lowest " " " "	33,003.
Variation in *per centum* of highest,	38.

Two experiments on iron taken from the exploded steam-boiler of the "Red Jacket," resulted thus:

Average breaking weight, lbs. per sq. inch,	49,000.
Highest " " " "	56,000.
Lowest " " " "	42,000.
Variation in *per centum* of highest,	25.

The testing machine used was constructed by Messrs. Riehle Bros., of Philadelphia, and is similar to that illustrated in No. 5, Vol. LXIII, of this JOURNAL.

Referring to previous tests of iron from the Westfield's boiler,* it will be noticed that these experiments reveal a greater variation in strength than was there found, while exhibiting about the same average strength, and thus tend to confirm the conjecture expressed by Prof. Thurston in connection with the report of the first series of tests: that a weakening effect may be produced by the wrenching and twisting accompanying explosions. Mr. F. B. Stevens, and other engineers of experience, express the same opinion, and still further confirmation is afforded by the result of the tests of iron from the "Red Jacket," that boiler having been constructed of carefully selected American iron of the best brands known in the market.

A BOILER EXPLOSION.

By B. F. Isherwood, Chief Engineer, U. S. N.

The following account of the explosion of the locomotive "Cheltenham," on the North Pennsylvania Railroad, is given by the only survivor of the seven men who were on the engine when the catastrophe occurred, and may be interesting as showing its true cause, and the frequent state of facts which preceded it.

The explosion took place at 9 hours 48 minutes A. M., February 2d, 1865. The engineer had 20 years' experience, and was considered well qualified and reliable. The diameter of the cylinders of the engine was 19 inches; that of the driving-wheels 48 inches. The evaporative capacity of the boiler was very great, and its tubes were slightly defective.

Just previous to the explosion, the furnace contained a moderately heavy fire of Lehigh anthracite, and its door was open. The feed-pumps were in regular operation, and the gauges showed a maximum water-level with a steam pressure of 130 pounds per square inch. Under these conditions, the engine had completed the ascent of a very steep grade at the speed of about 12 miles per hour. After passing the summit and commencing the descent on the other side, the engineer closed the throttle-valve, shutting the steam as completely off as practicable for the cylinders, when, in a few minutes, the boiler exploded with great violence, turning entirely around upon the track, and having its fire-box end torn into pieces. The sound of the explosion resembled that of gunpowder.

* Prof. R. H. Thurston's Investigation and Report.—Journal of Franklin Institute, Oct., 1871.

The facts of the case when the explosion occurred, therefore, are:

1st. The engine was in operation at the instant of the explosion, and had been for a considerable time previous.

2d. The boiler was well filled with water, and the feed pumps were continuing the supply.

3d. There was a maximum pressure in the boiler, and a good fire of anthracite in the furnace to maintain a rapid generation of steam; the evaporative capacity of the boiler being large.

4th. The steam was suddenly and almost entirely shut off from the cylinders, so that any further generation of it went to increase the already maximum pressure in the boiler.

5th. In a few moments after shutting off the steam, its gradual accumulation reached a pressure superior to the strength of the boiler, which, as might have been expected, gave way, with the usual detonation and destructive effects of a steam-boiler explosion.

There can be no doubt that the explosion was caused by the simple closing of the engine's throttle-valve while the fire was in steady action, the generation of steam being thus rapidly continued in the boiler, while very little of it was removed. As the pressure was at the maximum when the throttle-valve was closed, it was a question of only a very few moments when the explosion must occur, and that time was made the less by the small amount of steam room in the boiler caused by the high water level, and by the action of the pumps continually decreasing that amount. Of course, the reduction of the furnace-draught, and, consequently, of the rapidity of the combustion, by the want of nearly all the usual blast in the chimney, must not be overlooked, nor the cooling effect of the feed water pumped in; both of these causes, however, could only postpone the explosion a little while, which was inevitable from the simple over-pressure gradually produced by the circumstances stated.

New York Elevated Railway.—This enterprise, which at first seemed to be troubled by numerous drawbacks, is now in so fluorishing condition that the company has been compelled, by the increase of travel upon its route, to put on an extra number of trains, and their cars are at present making 40 trips per day each way. Turnouts are being erected at various points along the route, which will permit of trains passing each other, and thus practically double the facilities for transportation. The road is stated to be financially prosperous.

Chemistry, Physics, Technology, etc.

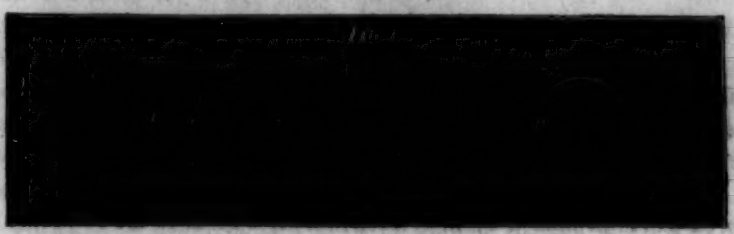
REMARKS ON PROF. E. J. HOUSTON'S PAPER, ENTITLED "ON THE NATURE OF WHITE LIGHT."

By Prof. William A. Anthony.

I have read with interest an article in this Journal, "On the Nature of White Light," by Prof. Houston. I think he has over-estimated the difficulties in the way of the acceptance of his second conception, that white light is produced by a compound vibration, which is the resultant of the vibrations of all the prismatic rays, and in this article I will endeavor to show that the phenomena observed are not inconsistent with that view of the constitution of the solar ray.

Prof. Houston says, "If the prismatic tints do not exist in white light as separate waves, but as components, then the resultant must be a mean of some kind of these components." "Out of the multitude of waves of varying lengths, there must result one whose length is the average length of the whole, and this resultant wave must, of course, have a definite rate of vibration and wave length."

With this conclusion I cannot agree. No single vibration can represent the resultant of several simple vibrations of varying lengths, but such a resultant must be considered as including the whole series of changes of velocity and amplitude to which a given ether particle is subject on account of the varying influences to which it is exposed in the compound ray. To illustrate my meaning, take the simple case of the co-existence of two vibrations, whose rates are respectively as 2 : 3. In figure 1, the two regular sinuous lines, A B C and A b c,



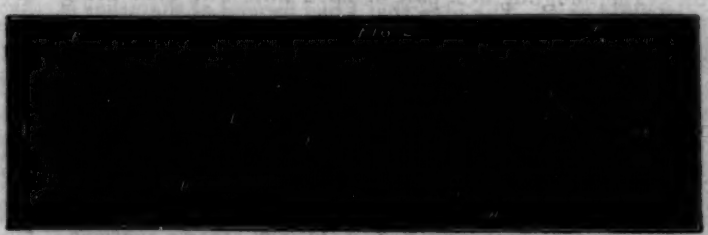
may represent the two vibrations; the irregular dotted line, A *m n o p r s t*, whose ordinates are the algebraic sum of the ordinates of the two regular sinuous lines, will then represent the resultant vibra-

tion. A little inspection of the figure will show that in the time represented by the line A *t*, the velocity of the vibrating molecule undergoes very great variations, and that no two of its vibrations are performed in the same time. At *t* the molecule begins again the same cycle of changes as at A. If A B C and *a b c* represent the vibrations of two sounding bodies, it is evident that the effect upon the ear produced by their co-existence would not be complete until the molecules of air had passed through at least one series of changes of velocity. The same would be true of light as for sound; the visual impression would not be complete until the ether molecule had completed its cycle of changes, and the whole motion of the molecule included in this cycle of changes must therefore be considered as the resultant vibration. The above, it is true, is but one case, and that a very simple one; but the same result would be reached if the resultant of five, ten, or a hundred colored rays were constructed in a similar manner. That resultant would not be found to be a regular vibration of mean length, but a vibration whose length varied through a series of changes repeated at regular periods. Such a resultant vibration would be entirely unlike any of the regular vibrations producing the prismatic colors, and white light should not, therefore, be found in any part of the solar spectrum.

I cannot understand how Prof. Houston arrives at his conclusion that different kinds of white light would result from the combination of different pairs of complementary tints. Any two complementary tints are themselves the resultants; the one of a certain portion, and the other of all the remaining portion of the components of white light. The mingling of a pair of such tints will then bring together all the components of white light, and will produce the same result, however these may have been previously grouped; for when it is desired to determine the resultant of a group of forces or motions in mechanics, there is nothing more common than to divide these into smaller groups, to find the resultant of each of these smaller groups separately, and then to determine the resultant of these resultants. Such a method would be entirely inapplicable if a different grouping of the component forces or motions should lead to different results. The colored bands produced by interference do not seem to me to present any obstacle to the acceptance of the theory of white light in question. Referring again to figure 1, let us designate the ray represented by the resultant wave, by X_1, and suppose another ray, X_2, following the same path, to be so related that their vibrations are everywhere in opposite

phases, *i. e.*, suppose the second ray to be represented by a line starting from the point A, and having its ordinates everywhere equal and opposite to those of the dotted line. It is evident that the two rays would mutually destroy each other, and total darkness would occur. Such a result is realized at the point of contact of the lense and glass plate in the experiment for the production of Newton's rings. At that point of contact the air is not absolutely excluded, though it has became infinitely thin in relation to the length of a light wave even. A ray of white light passing through the lense is partially reflected upon emerging into this thin layer of air, and since the reflection takes place at the surface of a rarer medium than that through which the ray was passing, the vibrations of the reflected ray are in the same phase as before reflection. Another portion of the light passing through the thin layer of air is reflected from the surface of the glass plate, and since this reflection takes place at the surface of a denser medium than that through which the ray was passing, its phase is changed. Now, from the extreme thinness of the film of air, these two reflected rays start practically from the same point in opposite phases, realizing exactly the case that I have supposed above, and it is well known that a black spot always appears at the point of contact of the lense and plate, when Newton's rings are viewed by reflected light. The same effect is observed with a soap bubble at the moment before bursting, when the thickness of the film has become very small in relation to the length of a light wave.

Now, let us see what would be the effect if one of the rays, X_2, were retarded by part of an undulation. In figure 2, let A B C, etc.,



represent X_1, being in all respects the same as in figure 1. Let *a b c d*, &c., represent X_2, supposed to have started in advance of X_1 by an interval, A *d*, Fig. 1 (i. e., X_1 is retarded by this interval), and in the opposite phase. The line *a m n o p*, &c. (figure 2), represents the resultant wave, and it will be seen that its undulations are all uniform,

and equal in length to those of the component, A B C, &c. (figure 1). If the lines representing the component vibrations of X_1 and X_2 had been drawn in figure 2, it would have been seen that the two components of the less wave length meet in opposite phases, and therefore destroy each other, while the components of the greater wave length, meeting with but little difference of phase, produce the corresponding color with increased intensity. This case is realized when a compound ray is reflected from the outer and inner surface of a film of such thickness as to produce a retardation equal to the wave length of one of the component colors. The same reasoning and same construction would apply to it if there were five, ten or ten thousand components, and the same result would follow. Bands of different colors from interference may, therefore, be explained upon the hypothesis of resultant waves. It must be remembered that I mean by a resultant wave, not the space occupied by the ether particles that are performing a single to and fro movement, but the distance along the line of the ray necessary to include molecules representing all the changes of velocity to which a single molecule is subject.

Now, one word in regard to the third hypothesis discussed by Prof. Houston, that the different colored rays exist as separate entities in a beam of sunlight. That a ray of white light, if I understand him, consists of a bundle of colored rays, in each of which the molecules of ether are vibrating at the rate proper to that color, independently of the vibrations going on around it. This, with my conception of the nature of the ether, seems a mechanical impossibility, and I have been unable to form any conception of a medium in which such a state of things could exist. The idea that I had formed of the ether is, that it is a highly elastic fluid, whose motions, vibrating or otherwise, are subject to well known mechanical laws. Not a molecule in sucha fluid, could be disturbed without disturbing all the molecules around it, and the motion of any molecule at any moment must be that due to the resultant of all the forces acting upon it. I cannot conceive of the molecules in the immediate vicinity of each other in such a fluid, vibrating at different rates, without influencing each other's motions. On the other hand, the composition and resolution of forces and motions are very common operations in mechanics, and the co-existence of sound waves in air furnishes examples, whose complexity might well remove any doubt of the possibility of such a resolution in the case of white light. The practiced ear can readily distinguish the notes of each separate instrument of a large orchestra, yet it would be preposterous

to suppose that there are, within the auditory canal, particles of air that vibrate in unison with a particular instrument, and are uninfluenced by all the others.

I might take up the phenomena of polarized light, and show how these may be explained upon the theory of a resultant vibration; but I do not see that Prof. Houston finds, in polarization itself, anything that he considers inconsistent with that theory. The interference of polarized rays may be explained as in the case of ordinary light.

Since writing the above, I have received the October number of the Journal, and find in it an article on the "Illustration of Resonances," &c., by H. A. Rowland, in which is described an experiment that furnishes a fine illustration of the composition and subsequent resolution of vibrations. Referring to his figure and explanation on page 277, the movement of the wire under the influence of the vibration of three of the heavy balls is a compound vibration, which is resolved into its components in the vibration of the small balls.

The method described by Mr. Rowland seems to me full of promise for the illustration of this subject. I think I see already how it can be adapted to the illustration of interference phenomena, and I cannot forbear thanking him for the suggestions it contains.

Physical Laboratory, Iowa Agricultural Society,

EXPERIMENTS ON HEAT, RADIATION, &c.

By Robert J. McClure, C. E.

(Continued from page 359.)

Professor Tyndall, during one of his lectures, heated a leaden weight by repeatedly raising and dropping it. If that weight cooled at each descent, to what cause shall we attribute its final increase of temperature?

Let us apply our theory to this case, and let us, for the sake of simplicity, suppose the weight raised to such a height that after striking the ground its temperature is raised 1°. A string is attached to the weight and passed over a pulley at the ceiling of the room. A certain amount of muscular force is applied to the other end of the string and the weight rises; its temperature constantly increases until, at the highest point, it has risen 1°, then the string is run out, and the weight falls; the temperature sinks steadily until, when the mass is on the point of touching the ground, it has fallen one degree, that is, reached its initial temperature, but the mass now possesses the velocity due to the height from which it fell, or what is the same

thing, due to the muscular force exerted in raising it, and that motion of the mass, when converted into molecular motion, increases its temperature one degree. Each subsequent raising and dropping adds another degree to its temperature, and finally, at the conclusion of the experiment, the body holds in addition to the heat it possessed at starting, an amount of heat equivalent to the whole muscular force exerted upon it.

If the same law holds with regard to cosmical masses, which our experiments prove with regard to masses falling into the earth, that is, generally :—

If two masses in space approach each other by virtue of a mutual attraction, then at any point of time they have lost an amount of heat equal to that which would be generated by their impact, if moving in opposite directions with the velocity acquired at that time. If this law be true then the meteoric theory of the sun's heat falls to pieces. If this law be not true—if the velocity of a body thrown upwards from the earth's surface be not converted into some other form of motion—then is not the principle of the conservation of force true. To say that this velocity is converted into potential energy, while maintaining that potential energy is not, itself, any *form* of motion, but a *cause* of motion, is equivalent to stating that a mass of matter might be changed into something which is not any form of matter, but a cause of matter. Concerning force in the abstract we have no conception. Concerning force as a cause of motion we have no more idea than we have of God himself.

If a marble, while moving rapidly, be constrained by the rim of a table to assume a circular orbit, it manifests, at every point in its path, a tendency to continue on the tangent at that point, and this tendency produces what we call a pressure of the marble against the rim. When a weight rests on a table, it produces what we call a pressure of the weight against the table. If the rim in one case, and the table in the other, were instantly removed, the result would be the free motion of each moving body in a straight line, but we have no more right to assume that the pressure of the weight against the table was the *cause* of its motion than we have to assume that the pressure of the marble against the rim was the cause of the marble's motion.

The wheel of a large gyroscope, at rest, may be made to change its plane by a weight of a few grains, but the same wheel, while revolving rapidly, will sustain a weight of several pounds, or, what is

the same thing, produce that pressure against the weight; the pressure here is evidently not the cause, but the effect, of the gyroscope's motion.

A silver medal, sustained by a twisted string, between the poles of an electro-magnet, and revolving under the influence of the string's torsion, is brought instantly to rest when a current of electricity is sent through the coils of the magnet, and a considerable pressure against the rim of the medal is required to produce rotation around a vertical axis. The instant, however, that the current of electricity is cut off, the medal resumes its motion, though actuated only by the string's torsion.

The analogy between the conduct of the gyroscope and the medal is such that though our unaided senses can discern motion, neither in the magnet nor the medal, we are persuaded that the current of electricity induces in the particles of the medal a motion similar to that possessed by the particles of the gyroscope, that is, a revolving motion around axes parallel to a line joining the poles of the magnet.

Such motion would produce all the effects observed, and no other physical cause, with which we are acquainted, would account for the phenomenon. A boat in the current of a river may be held at rest by its anchor, or it may be held by a weight whose pressure would balance the pressure of the stream against the boat.

In these examples we have pressure as the result of motion in the case of the marble and the boat, and we have inertia as the result of motion in the case of the gyroscope and the medal.

It is generally believed that the pressure produced by compressed air, by the centrifugal force of a revolving body, by the action of a heated bar or the limb of an animal, is the result of motion in the body producing it.

The analogy between any two of these cases is not greater than the analogy between the action of a weight and any of them; for what reason then shall we say that the pressure exerted by a weight is the cause and not the effect of motion.

Wherever, in our experiments on the conversion of force, the process of conversion can be followed clearly through different portions of matter, we find in every stage that this force exists as a form of motion. It is possible that forms of motion may exist of which our senses, aided by the most refined instruments, can take no cognizance; but in enunciating the principle of the conservation of force we can only affirm that motion is the invariable antecedent of motion. The

limit of physical investigation is reached when, having given the forms and quantities of motion of any number of elements, we can predicate the resultant motions when another element, having any form of motion, is added.

A few pages back I referred to Herschel's estimate regarding the quantity of heat received by the earth from the sun. The instrument used in his experiments was a small, shallow cylinder filled with mercury, in which the bulb of a sensitive thermometer was immersed. The flat top of this cylinder was coated with lampblack and turned towards the sun for five minutes. Now it was supposed that during the whole time of exposure, his instrument was radiating heat in all directions into space, and to determine the amount lost by such radiation, he turned the face of the instrument for five minutes, both before and after exposure to the sun, to a point in the sky where it might radiate freely without receiving any of the sun's rays. In order to obtain the whole heating power, he added to the observed heating power the mean of the quantity lost in five minutes, during the observations in which his pyrheliometer radiated freely into space. It will be noticed that no account is here taken of the amount of heat carried off by the air. Would the quantity of heat so lost by convection materially affect the result? Would the pyrheliometer, supposing it to be surrounded by an absolutely non-conducting medium, indicate no higher temperature after its five minutes exposure to the sun than it did while suspended in the air?

A few days ago, when the thermometer stood at 60° in the shade, I placed another in the sunlight and found its temperature to be 80°; a small cloud of smoke, projected into the air beneath the bulb, rose rapidly along the sides of the tube, proving the loss of heat by convection. On placing this thermometer within a glass shade, and again exposing it, the temperature rose to 98°, notwithstanding that a considerable portion of the sun's heat must have been arrested by the glass; the limit, however, was not yet reached.

I enclosed a thermometer in a small test tube and packed the space around the bulb with iron filings; this test tube was then enclosed within another, containing at its lower end a small quantity of iron filings, and insulated from contact with it by means of plungers of cotton wadding; this was placed within a third similarly prepared ube, and the whole arrangement deposited in a glass case and exposed to the sunlight. The mercury rose slowly and almost uniformly until it attained a temperature of 195°.

Again I placed a single flat glass case, containing my thermometer, on the top of a metal plate, beneath which a lamp was burning the thermometer indicated, in the sun, a temperature of 166°, F. When a screen was interposed it sank to 126°, and afterwards rose to its original temperature, 166°, on the removal of the screen. I then raised the lamp until the thermometer showed 180° in the shade. The additional heat produced by the uncondensed sunlight raised the mercury to the limit of my thermometer, 212°. That is, as the temperature of the air was increased, or, what is the same thing, its convection capacity diminished, the heating power of the sun's rays seemed also to increase. In fact, as far as my experiments went, the sun's rays produced in any dark colored solid a temperature of from 15° to 40° above that of the air by which it was surrounded, and the higher the absolute temperature of the air the greater seemed to be the difference between sun and shade.

What then is the actual temperature which the uncondensed rays of the sun are capable of producing on the earth's surface, and what, supposing the laws of radiation to be true, must be the temperature of the sun itself?

During the long night of an Arctic winter the thermometer frequently sinks to a temperature of —50°, F. Let us suppose this to be the temperature which a mass on the earth's orbit would ultimately attain, supposing the sun to be annihilated. Now we have seen that the sun's rays are capable of producing, in such a mass, a temperature of 212°, F., that is, of raising it through 262°. According to the laws of radiation, if the heat of one sun will raise the mass through 262°, the heat of two equal and similar suns, at the same distance, will raise it twice 262°, and the heat of n suns n times 262°. But to produce in the mass the temperature of the sun itself it would require a whole firmament of sun matter, that is to say about 180,000 suns, and the temperature produced would be 47,000,000° F. Divide this by ten, by a hundred, and expose to such a temperature a mass, equal to the suns, of any substance within our knowledge, and in what condition would it exist? As vapor whose density would compare with the density of the Torricellian vacuum, as the Torricellian vacuum compares with lead, vapor which would permeate space beyond the limits of our vision. We know that no such temperature exists in the sun, and we know that the sun's density exceeds the density of water.

In fact, from whatever point we approach this question of radia-

tion, the gravest difficulties are met when we attempt to reconcile its laws with observed facts, and with older and better established laws in other departments of physics. I have searched philosophical works in vain for any direct proof of the existence of radiation. Where estimates of the earth's loss of heat from this cause have been attempted, they vary so vastly as to justify us in assuming that in probably all the cases, and certainly in all but one, the condition proper for conducting the experiments were wanting. So far as my researches extend, I failed to detect the slightest indication of loss by radiation. The instruments used were no doubt crude, but if even one-tenth of the heat we seem to receive from the sun were radiated into space they must unfailingly have announced it. In making these remarks as to the earth's radiation, it must not be supposed that I deny the power of a body in space to affect the temperature of another body at any distance whatever; but there is the most serious reason to doubt whether heat, or light, or gravity, or electricity, or any form of motion is ever *radiated* into *space*.

If the earth loses no heat by radiation then the sun loses none, and the theories of the sun's supply of heat are as worthless as they have been shown to be insufficient.

We experience, however, in the sunlight the sensation of warmth. We know that the earth's surface is hotter at the equator than at the polar circles, hotter by day than night, hotter in summer than in winter.

That there is a mutual action between earth and sun, one of the results of which is the development of heat on that portion of the earth's surface turned towards the sun, is undoubted. Does it necessarily follow that the sun daily loses an amount of heat equal to that developed on the earth's whole surface during twenty-four hours? That there is a mutual action between earth and moon, one of the results of which is the development of a power differing only in quantity from that produced by the sun, is also undoubted. Does it necessarily follow that the moon *loses* daily the amount of force required to pile up the waters of the ocean?

When a metallic sphere is caused to approach the charged prime conductor of an electrical machine, electricity is developed on the nearer surface of the sphere, and an equal amount of the complementary electricity is developed on the remoter surface.

The sphere may be twirled round any axis, yet so long as it retains the same position in space, the dividing plane of its electricities re-

mains invariable, and a point becomes alternately positively and negatively electrified as it passes from side to side of that plane.

No one supposes, in this case, that electricity is radiated from the prime conductor to the sphere.

No one supposes that at each revolution the conductor loses an amount of electricity equal to that developed on the whole surface of the sphere. Much less does any one suppose that the prime conductor radiates its electricity in all directions into space.

Let us substitute the sun for our prime conductor, and the earth for our sphere; then if it is admitted that the sun, by induction, could maintain the earth's illuminated hemisphere constantly charged with electricity, without any actual transfer of force from the sun to the earth, it must be admitted that the sun could equally well, without any loss of heat, maintain the same hemisphere constantly warmed, since electricity and heat are mutually convertible.

I believe it was Franklin who first observed that pieces of colored cloth, when exposed to direct sunlight, sank in a snowbank with velocities depending on the color; that cloth of any color sank more rapidly than white, and black most rapidly of all. During the cold weather last winter, I exposed to the action of the sun, on the ice of Rock River, portions of the following substances: copper, red chalk, sealing-wax; silver, iron (with white paper surface), brass, sulphur; iron, black pasteboard, shellac, and blackened cork.

After 48 hours exposure, I measured the depths to which these bodies had sunk. The copper was completely frozen over, and lay at a depth of $2\frac{1}{10}$ inches from the surface; the red chalk was also frozen over at a depth of $1\frac{5}{10}$ inch, while the sealing-wax, which possessed very nearly the same weight and color as the chalk, sank less than $\frac{3}{10}$ of an inch. The silver sank nearly $2\frac{1}{10}$ inches, and was frozen over; the iron with white paper glued to its surface sank $\frac{8}{10}$ of an inch, the brass 2 inches, and the sulphur not at all; in fact, the lower surface of the roll seemed to stand on a ridge a little higher than the surrounding ice. The iron sank nearly 2 inches, the black pasteboard $1\frac{3}{10}$ inch, and the cork $1\frac{2}{10}$ inch; these were all frozen over, but the shellac, which was very dark in color, and probably impure, sank only $\frac{7}{10}$ of an inch.

The bright tin lid of a blacking-box, which floated in less than $\frac{1}{4}$ inch of water, sank $1\frac{3}{10}$ inch, and was completely frozen over. It was at once evident that the sinking of these bodies was due neither to their weight nor to their color, nor to the combined effects of

weight and color. The white box-lid and the black cork, both of which floated in water, must actually have vaporized the ice in contact with them; while the shellac, sealing-wax and sulphur, bodies intermediate in color, but exceeding them in weight, sank very little or not at all.

If we examine a table of the specific electrical inductive capacity of bodies, or a table of their relative diathermacy, we shall find that the shellac, sulphur and sealing-wax stand at the head, while the metals occupy the other end of the list. It is natural, then, to suppose that the sinking of these bodies depends either on their diathermacy or their inductive capacity for electricity, if these are not the same thing or closely allied functions one of the other. Adopting the views of the believers in radiation, we should account for the sinking of the metals by saying that the heat radiated from the sun is intercepted by these athermous bodies, and communicated by conduction to the ice; whilst in the case of the diathermic bodies, the sun's rays pass not only through them but through the ice beneath, without producing any effect at the common surface of the ice and the superposed body. Now, at the commencement of the experiment I made an opening in the ice, and ascertained, with a pair of callipers, its thickness to be 14¼ inches.

In the evening of the same day, after the metals had sunk nearly an inch and a half, I again examined the ice, and found its thickness to exceed 14½ inches, the water in the opening itself being frozen an inch in depth, notwithstanding that an unclouded sun had shone upon it for more than eight hours. If heat sufficient to melt an inch and a half of ice on the surface had passed completely through to the water below, then we should have expected to find either the ice diminished an inch and a half in thickness, or the water raised in temperature by the amount of heat required to melt that thickness of ice. The temperature of the water was the same morning and evening; while the thickness of the ice, instead of being diminished, had actually increased. Unless we consider the action of the sun upon the earth analogous to the action of an electrified body upon another body in its vicinity, we can give no satisfactory explanation of this experiment. Regarded, however, in this light, all the results attributed to radiation can be accounted for, and many phenomena where force seems to disappear without producing an equivalent force find their solution.

I believe that the terms positive and negative, when applied to elec-

tricity, may be regarded as analogous to the terms hot and cold; as expressing difference in the quantity, but not in the form of motion called electricity. If a body possess more of this form of motion than the earth's surface at any point, it is said to be positively electrified with respect to that surface; if it possess less, we say that it is negatively electrified.

When a long wire, connecting the positive and negative surfaces of a Leyden battery, is cut at the centre and at each end, and a discharge sent through it, a spark appears simultaneously at each of the terminals, and a little later at the centre. This fact has been adduced as favoring the theory of two fluids, or rather of two forces acting in opposite directions. The result, however, seems to be equally a necessity of the plus and minus hypothesis. When a bar is heated at one end and cooled at the other, both heat and cold appear to travel towards the centre. We know, however, that the appearance is caused by successive portions of the neutral part of the bar giving up their excess of motion to the cooled end, and successive portions on the other side receiving the excess of motion from the heated end. In a similar way the neutral wire at the negative end of the Leyden battery gives up its excess of motion to the negative surface at the same instant the other portion receives the excess of motion from the positive surface, sparks being simultaneously produced at the points of rupture. The wires at this instant virtually form continuations of the respective surfaces of the battery. A spark passes across the central break, and equilibrium is restored.

Viewed in this way, the greater the wire surface, battery surface remaining constant, the feebler should be the central spark.

Let us now return to the consideration of the sun's action upon the earth, premising that the sun and earth stand to one another in the relation of electrified bodies, and that the terms positive and negative express excess and deficiency of motion. If heat is developed on one-half of the earth's surface in consequence of that surface being electrified, then it is reasonable to suppose that cold should result on the opposite hemisphere where the complementary electricity is induced.

If, during the day, heat is developed most copiously in bodies with rough surfaces, in bodies on which a high degree of induction can be produced, then during the night cold to a corresponding extent should be developed in the same bodies. If large portions of the substances which I previously exposed to the sunlight were spread upon the

ground while dew was falling, I should expect to find the moisture most copiously deposited on those substances which sank in the ice most rapidly. It would be useless to experiment with small surfaces, for the faintest breeze and the constant tendency of the colder air to spread over the ground by virtue of its greater density, would render the deposition of moisture nearly uniform on all except very large areas of homogeneous surfaces.

A question bearing on this subject of radiation has frequently presented itself to me: Why is it, if the sun's heat pours uniformly and unceasingly, like a constant stream, against one hemisphere of the earth, that we experience such fluctuations in our climate, such difference in our seasons, from year to year? Why, if the cause be constant, should not the effect be constant? Can it be claimed that the small residual disturbances after any time, and the minute physical changes occurring on the earth's surface, should so react upon the cause of their existence as to affect so vastly our climatic records? I believe, if this state of things existed, if the sun's heat streamed constantly and without variation against our planet, that, though seasons might gradually change, in the lapse of centuries, at every return to any point in its orbit, the temperature of the earth, by day and by night, the winds and rains, and all the attendant meteorological phenomena, would recur.

Reverting now to the hypotheses advocated in this paper, and following these hypotheses to their legitimate conlusions, we should expect to find recurrence of similar seasons in all the planets at those periods during which the elements of the solar system occupy the same relative positions in space. We should expect to find that when the sun's rays strike vertically on any portion of the earth, producing intense heat, cold to a corresponding extent should be developed on that space where the rays produced intersect the surface of the opposite hemisphere. We should expect to find the mean temperature of the earth at aphelion several degrees higher than at perihelion. We should be obliged to regard all bodies, oxygen, hydrogen, coal, gunpowder, not as substances endowed with potential energy, but as substances possessing in themselves, at every instant, all the motion they are capable of producing by combination. In the union of one pound of hydrogen with eight pounds of oxygen, to form water, sufficient heat is evolved to raise nine pounds five million feet high. We must therefore assume that every part of this mixture possessed before combination a velocity exceeding 18,000 feet per

second. And so, in determining the difference or the identity of any of the substances which go to make up our planet, we must consider not only the elements which enter into their composition, but also the forces with which these elements are combined. Concerning the sun's action in dissolving such combinations and in endowing each element with the velocity and motion of its kind—concerning the manner in which, possessing that velocity, the elements are held together, we know nothing; but do we know anything concerning the sun's action on the maintenance and reproduction of life? Do we know why nitrate of silver blackens in his rays? why, under his influence, the leaves of plants assume their various tints of green, and their flowers such infinite variety of color?

Does the theory of radiation give any clue to the explanation of these phenomena? That theory, followed to its ultimate consequences, reduces all things to a state of sameness and uniformity, "weary, flat, stale and unprofitable."

It foreshadows loss and darkness and death, not to our system only, but to the universe; for heat without cold, light without darkness, any form of energy without its complement, is death.

As our knowledge advances, duality in all the forces of nature becomes apparent. Heat is not more a source of power than cold. A state of things might have existed on earth, or may at present exist on some other planet, where cold- instead of heat-producing agents represent the source of power.

The earth, if left to itself, would ultimately attain a uniformity of temperature throughout; and one of the sun's functions would seem to be to prevent the acquisition of such a state, in perpetually disturbing the equilibrium of molecular motion—intensifying it at one place, diminishing it at another; extracting it from inorganic compounds, storing it away in living organisms; but adding nothing to or subtracting nothing from the earth's total of matter or motion.

There is one other point to which I shall briefly allude before closing this paper. The assumption that two masses, in attracting each other, lose in any time the amount of heat competent to produce in them the velocity acquired at that time, would seem to conflict with the law of gravitation. That law is, I believe, correctly expressed in the statement that every particle of matter in the universe attracts every other particle with a force whose direction is that of the line joining the two, and whose magnitude is directly as the product of

their masses, and inversely as the square of their distance from each other; or, expressed in symbols:

If g represent the force of attraction between any two particles at distance r, then $f = g\frac{r^2}{x^2}$ represents the force at distance x.

To determine the velocity, v, at any time, we have $f = g\frac{r^2}{x^2} = -v\frac{dv}{dx} = -\frac{1}{2}\frac{dv^2}{dx}$ or $v^2 = -2gr^2\int\frac{dx}{x^2}$ and taking as limits of the integration $x = x_1$ and $x = r$, we have for the velocity acquired between distance x_1 and distance r,

$$v = \sqrt{2gr\left(1 - \frac{r}{x_1}\right)}$$

Let g represent the velocity acquired in one second by a body falling on the earth's surface, and r = the earth's radius; then the velocity of a body falling on the earth's surface from an infinite distance would be represented by $v = \sqrt{2gr}$.

Again. Since the attraction of a uniform spherical shell upon an internal point is nothing, we should have, assuming the earth to be a homogeneous sphere, the attraction, f, upon an internal particle at distance x from the centre $= g\frac{x}{r}$ and the velocity acquired by a body falling from the surface to the centre $= \sqrt{gr}$, and from what has gone before, the velocity acquired by a particle falling to the earth's centre from an infinite distance

$$= \sqrt{gr}(1 + \sqrt{2})$$

Let us now suppose the earth's temperature raised so that r changes to u r, the mass of course remaining constant; then the final velocity of a body falling to the centre from an infinite distance

$$= \sqrt{\frac{gr}{\mu}}\left(1 + \sqrt{2}\right)$$

That is to say, the final velocity, or the force developed by the impact of two bodies attracting each other through an infinite distance, *is* a function of the original temperature of the bodies. Unless qualified in this manner, the law of gravitation assumes both the creation and the destruction of force.

ON THE UTILIZATION OF WASTE COAL.*

By William H. Wahl.

The desirability of effecting the economic utilization of the coal waste daily accumulating in the anthracite mining regions is universally conceded. This waste, to take a moderate estimate, is not far from 50 per cent. of the total production. The question has for years attracted the attention of inventors, of those interested in the mining and transportation of coal, and others, the result being the announcement and testing, from time to time, of a number of plans for satisfactorily attaining this object. It is, however, only within the past few years that the growing importance of the problem has attracted general public attention to the attempts at its realization. With every expansion of the industries dependent upon coal for their existence, and therefore highly sensitive to the price of this commodity, the necessity for its successful solution will be enhanced. Thus far, however, it may be safely asserted, no process has been devised for this purpose which could be operated with a reasonable amount of success; a declaration which is verified by the fact that, after a trial of a few months, each has invariably been abandoned, though it is very probable that there are some among the hundred odd patents granted in this country alone under this heading which, under the stimulus that would be afforded their owners by any considerable increase in the marketable value of coal, would prove to be of practical value.

The difficulties in the way of effecting the utilization of the anthracite waste are very great. They involve not only the question of economy of manufacture, which is absolutely controlled by the ruling price of coal at the mines, and which, from a financial standpoint, must necessarily stamp any such plan with a speculative character, but they reside also in the chemical and physical nature of the material.

The processes for the utilization of the anthracite waste consist universally in the employment of a foreign material or materials, which shall serve the purpose of a cement to bind the loose particles of the waste together. The cements heretofore used have been both of mineral (incombustible) and of organic (combustible) character. In the majority of instances, as is usually the case with a field of invention just ripening into importance, the patentees of such processes display a characteristic ignorance of, or lofty indifference to,

* From the American Exchange and Review, Oct., 1872.

the conditions of the problem they profess to solve. The number and variety of substances which have been secured by inventors, either as cements, or to aid in the cementation or combustion, is well calculated to surprise one unfamiliar with the literature—if such an expression is allowable when applied to patent office records of the subject. The several alkaline substances and their silicates seem to have been held in special favor, since they repeat themselves, with some modifications, in several places. Lime, either alone or with some subsequent chemical alteration into carbonate, sulphate, or silicate, is claimed; or plaster-of-paris or hydraulic cement are used directly. Clay must also be named. Among organic substances may be named pitch, coal-tar, resin, the Trinidad bitumens, asphalt, petroleum residues, dextrin, glue, Grahamite, &c., while as accessories, employed either to assist cementation or combustion, we have sawdust, chaff, flour, blood, cow-dung, starch, sand, saltpetre, and other substances too numerous to mention. Comparatively few of these processes have ever reached a public trial, as indeed few deserve it, and of those which have received attention, none have been more than indifferently successful, either from inherent deficiencies or from commercial reasons. We give a brief survey of some of the more important processes.

For a number of years the bituminous or semi-bituminous waste from the mines of Germany, France and Belgium has been to a considerable extent successfully utilized by mixing with it from 15 to 30 per cent. of ordinary moist clay, and pressing this plastic mass into forms of any desired shape and size. The product thus obtained, though of inferior heating quality, still secures a ready market, owing to the high price of coal in the countries named, where it finds employment not only for household purposes but also for steam generation. Quite recently a similar process, by which the percentage of cementing clay is reduced to a minimum, has been brought out in this country by a Belgian engineer familiar with the methods employed abroad. His plan, according to description, is to employ about seven per cent. of clay with the dust, and, after thoroughly mixing the materials, to bring the mixture into a pressing machine, where it is pressed into cylindrical forms of convenient size, under considerable pressure. In order to protect the product from the disintegrating effects of rain or dampness, the inventor passes the lumps thus formed through a bath of rosin dissolved in benzine, obtaining in this way a thin hide of rosin upon the surface of the lumps, which effectually serves the purpose of excluding the water.

The plan, from its simplicity, aided doubtless by the favorable opinion expressed of its merits by a committee of the Franklin Institute, has received the favorable consideration of the Lehigh Coal and Navigation Company. The abandoned works of a former unsuccessful company, which will be named hereafter, situated at Nesquehoning, Carbon County, Pa., have lately been secured by the Lehigh company, for the purpose of giving the plan a thorough trial. The expensive machinery of their predecessors has been or is now in process of being modified to suit the present plan.

The same inventor has labored zealously in this field for a number of years in the South, having for some time successfully manufactured, at Nashville, Tenn., an artificial fuel, by the same general process, from the Southern bituminous coals, until certain business complications conspired to raise the price of the waste to so high a figure that the manufacture was abandoned.

The other plans (employing mineral cement) as yet made public, include those using an alkaline silicate (water-glass) either alone, or in connection with a chloride of calcium or magnesium, or both, an hydraulic cement, plaster-of-paris, etc. As far as the knowledge of the writer extends, none of these have yet passed through the ordeal of practice, and should this have occurred with any one of them, it has simply resulted in a failure. All such attempts must prove unsuccessful, from the fact that either the combustible character of the coal waste is so considerably reduced by the mixture with it of from 10 to 20 per cent. of non-combustible materials, that the product can only be burned with difficulty, necessitating either constant attention or an artificial draught, or the cement employed fuses in the heat of the furnace, and, coating the cemented particles with a liquid glass, prevents the access of the air to it, preventing its combustion, and finally forms an objectionable clinker. For reasons to be specified below, the writer is of the opinion that no process employing a mineral cement will ever be more than indifferently successful, not excepting the clay process, of which so much is anticipated.

It is well known that coal of any description, and especially when in the finely comminuted condition of dust, if exposed for some time to the combined action of air and moisture, gradually deteriorates in heating quality. This deterioration is produced, first, mechanically, by the slow admixture with it of dust and dirt carried by the winds; and, secondly, by a slow process of oxidation, analogous to the rusting of iron, which infallibly attends the exposure of any readily oxi-

dizable substance to atmospheric influence. From both of these causes the heating quality of the coal waste is slowly reduced (or its percentage of ash, to state the case in other words, is slowly increased), and this reduction in quality grows greater and greater with the time of its exposure. With bituminous lump, Varrentrapp estimates, from careful experiments, that the loss of heating power, from chemical causes alone, may even reach 25 per cent., and for purposes of gas production 45 per cent. With anthracite lump, the deterioration from this one cause alone will be far less than with bituminous; but from both the causes named, it must be evident that, with the anthracite in form of waste, the deterioration must in most cases be considerable enough to gravely influence the success of any plan having in view its manufacture into artificial fuel. By the employment of dust from freshly mined coal, or of a judicious mixture of the old waste with the new, the difficulty from this source may be partially overcome. But no scheme having for its object the utilization on a large scale of the vast waste heaps of the anthracite region, can afford to be blind to the objection here named, since it is mainly from more or less deteriorated materials that the product to be utilized must be obtained.

Instead, therefore, of employing in the cementation of the waste a substance incombustible in itself, and which directly adds so much to the percentage of ash, and still further detracts from the heating quality of the waste, the path seems pointed out to inventors to seek about for some cementing material which, being itself combustible, will improve the heating qualities of the poor waste, and which must be free from certain collateral objectionable features incident to the problem. This fact seems to have been recognized long ago, as the list of combustible cements given on a previous page would indicate. Whatever of historical record there has come to our knowledge with regard to their trials, however, is equally unfortunate with the mineral cement processes. In some of the European countries only, have the attempts to employ coal-tar, pitch, resin, and kindred substances to bind the loose particles of dust into a coherent mass been successful. In this country it has several times been essayed to apply such a process to the utilization of our anthracite waste, but all have signally failed.

Several years ago a company was formed with this object in view, by whom the extensive works at Nesquehoning, Carbon County, Pa., referred to in a former portion of this article, were erected. They

employed a mixture of waste anthracite with coal-tar. This, after the most thorough mixture which could be attained (with the aid of heat), was pressed into suitable forms, and subsequently transferred to an oven, in which it was subjected to a baking process. From the testimony of several engineers, superintendents, and others who used it, it appears that the product, in spite of the increment given to its heating quality by the addition of coal-tar, was but an inferior steam generator. Whether the only partial carbonization of the tar by the baking process allowed the offensive coal-tar odor to be perceived or not, is a contingency not known to us; but it will readily be granted that unless this carbonization was complete, the introduction of the product for the household was impossible from the outset. It is most probable that the complicated character of the process, and the number of details requiring personal attention of workmen, aside from any consideration of the quality of the product, rendered the expense of its manufacture too great to permit of a successful competition with coal, and contributed mainly to the abandonment of the enterprise, which shortly followed. The failure of this, the best organized effort of any yet made to solve the problem of the waste heaps, would seem to indicate that, though similar plans have been and are still in successful operation in continental Europe, the cost of mining coal with us is yet too low to admit of the employment of a tarry or resinous cement to utilize our anthracite waste, even admitting that the fuel produced were of a satisfactory quality.

Of the other patented processes but few are worthy of mention; the great majority read too much like kitchen recipes to deserve serious consideration, as a glance at the list will show.

It is of interest to note that the first reasonble process to utilize this material originated with Mr. Bessemer, in England, where the demand for some such process will be more than ever urgent, now that the English coals have lately risen so considerably in price. Mr. Bessemer's process is for the manufacture of an artificial fuel from bituminous waste, by employing a peculiarly constructed furnace, having a device somewhat like an endless-chain pump, arranged horizontally, upon the successive sections of which the bituminous material, without foreign admixture, is fed in from a hopper above, and is taken continuously from the furnace in a semi-caked, plastic condition, and pressed in suitable forms or moulds, which are then ready for use. This plan has received considerable praise from scientific critics, of which it is indeed well worthy. It is now stated to be in successful operation in several large manufactories in England.

There remain finally to be mentioned, several American processes for utilizing coal waste by the use of Grahamite as a cement, which, as far as a judgment of their merits may be formed without the crucial test of practice, may ultimately prove to be satisfactory.

With us, however, for the present, this field of industry lies fallow for want of a cultivator.

Franklin Institute.

Proceedings of the Stated Meeting, June 19, 1872.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the Chair.

The minutes of the last meeting were read and approved.

The minutes of the Board of Managers were submitted by the Actuary, as well as the minutes of the several Committees.

He also reported from the Library Committee the following donations for the month ending June 1st:

From the Royal Astronomical Society, London, England, their Monthly Notices for April, 1872. From the Societé Industrielle de Mulhouse, their Bulletin for January, February and March, 1872. From the Academy of Natural Sciences, of Philadelphia, their Proceedings for October, November and December, 1871. From The Corps des Ponts et Chaussees et des Mines, their Annals for January, February and March, 1872. From the Academy of Sciences, Paris, France, the Comptes Rendus for January and February, 1872. From the Society for the Encouragement of National Industry, Paris, their Bulletin from October to December, 1871. From the Imperial Austrian Geological Survey their Year Book for November and December, 1871. From The Royal Institution of Great Britain, London, their Proceedings, Vol. 6, Parts 3 and 4. From A. Daul, Esq., Philadelphia, samples of Mosaic work from the 10th, 11th and 12th centuries, and the Annales de Physik et Chimie for January and February, 1872, from the Editors.

The President then announced that the Committee appointed to Investigate the Modes of Rating the Horse-power of Steam-boilers were ready to report finally.

Mr. Edward Brown, as Chairman, then read, on behalf of the Committee, a lengthy report upon the subject, containing the results

of inquiries extending over more than a year. Upon the conclusion of the Report, it was, upon motion, resolved that the thanks of the Institute be tendered to the Committee for their valuable paper, and the zeal displayed in its completion, and that the Report be published for the benefit of the members interested in it. It was further resolved, that the October meeting of the Institute be fixed as the evening for discussing the Report.

The Secretary then presented his Report on Current Items of Interest in Science and the Mechanic Arts.

Whereupon the meeting was, on motion, adjourned.

WILLIAM H. WAHL, *Secretary.*

Proceedings of the Stated Meeting September 18, 1872.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the Chair.

The Actuary submitted the minutes of the Board of Managers, and reported that since their last meeting, held June 12th, 1872, the following donations had been received into the Library:

From the Society of German Engineers, Berlin, their Journal for April and May, 1872; from the Meteorological Office, London, the Reports from 1867–70, also Instructions for Meteorological Telegraphy, Quarterly Weather Reports 1–4; Contributions to our knowledge of the Meteorology of Cape Horn and the West Coast of South America; Currents and Surface temperature of the South Atlantic Ocean; On the use of Isobaric Curves; from the Society of Architects and Engineers of Hanover, Mediæval Architectural Treasures of Lower Saxony; from the United States Department of the Interior, The Geological Survey of Montana and Wyoming, by F. V. Hayden; from The Royal Astronomical Society, of London, their Monthly Notices, No. 8, 1872; from the United States Treasury Department, Washington, Statistics of Mines and Mining, by R. W. Raymond; from the Royal Geographical Society, of London, their Proceedings, Vol. 16, No. 2, for 1872; from the Literary and Philosophical Society, of Liverpool, England, their Proceedings for 1870–71; from the Literary and Philosophical Society, of Glasgow, Scotland, their Proceedings, Vols. 1 to 7; from the Royal Society of London, England, their Proceedings, Vols. 3, 5, 6, also Abstracts of the Philosophical Transactions; from the Regents of the University of New York, The Annals of the Dudley Observatory, Vol. 2, New York State Library Subject-Index, Report for 1872, of N.Y. State Library; from the Austrian Society of Engineers and Architects, their Proceedings for 1872; from the Superintendent of the U. S. Naval Observatory, Washington, D. C., Reports of Observations on Encke's Comet, and Reports

of Explorations and Surveys for a Ship Canal between the Atlantic and Pacific Oceans.

The Actuary also reported, from the Minutes of the Board of Managers, the following: "Mr. Briggs, from the Special Committee on Corresponding Members, reported the following resolution, with a recommendation that it be approved by the Board of Managers:

"*Resolved*, That Wilhelm Heinrich Uhland, of Leipsic, Saxony, be nominated to the Institute for Corresponding Membership. On motion, the Resolution was approved."

The Secretary next read his Monthly Report on Current Novelties in Science and the Arts.

The President next stated that Mr. John B. Winslow had presented to the Institute, on behalf of the Boston and Lowell R. R., an Autograph of George Stephenson, with a drawing in his own hand of the first Locomotive-Tender ever perfected by him. Upon motion, the thanks of the Institute were presented to the Boston and Lowell Railroad for their valuable gift.

Mr. Thomas Shaw then presented some remarks upon a Water Bearing for relieving the end thrust of Shafts, which attracted considerable attention.

Mr. Shaw also moved that a Committee be appointed to investigate the Velocity of Sound. The President deferred the appointment of the same until the October meeting. Upon motion, adjourned.

WILLIAM H. WAHL, *Secretary.*

Bibliographical Notices.

The Nautical Gazette.—A weekly newspaper devoted to all maritime interests. Edited by B. S. OSBON. New York City.

To those among our readers who may be interested in perusing the freshest current news in this department, a knowledge of the existence of an excellent organ, devoted to naval interests of the country, will be of some importance. To these we can refer the *Nautical Gazette*, as a journal which will doubtless meet their wants more completely than any other. The newspaper in question is now approaching its fourth volume, and has a wide-spread and steadily increasing circulation. It is the organ of the ship-builders and naval engineers; devotes a fair share to yachting and naval news, in which latter direction it is all but official.

Some of the best ship-building talent of the land is ranked with its contributors—a fact which is evidenced in the excellence of its descriptive and engineering columns.